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REPORT OF THE INTERNATIONAL ATOMIC ENERGY AGENCY

Note by the Secretary-General

1. The thirty-eighth report of the International Atomic Energy Agency for the calendar year 1993 (GC(XXXVIII)/2) is submitted herewith to the General Assembly. Major developments since this report was published will be covered by the annual statement of the Director General of the Agency to the General Assembly. This report has been transmitted in accordance with the provisions of article III, paragraph 1 (a), of the Agreement governing the relationship between the United Nations and the International Atomic Energy Agency (General Assembly resolution 1145 (XII), annex).

2. As only a limited number of copies of this report are available, it has not been possible to make a full distribution. Delegations are therefore requested to have the copies transmitted to them available during the consideration of this item.

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* A/49/150.

GC(XXXVIII)/2

THE
ANNUAL REPORT
FOR 1993

INTERNATIONAL ATOMIC ENERGY AGENCY

THE
ANNUAL REPORT
FOR 1993

GC(XXXVIII)/2

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INTERNATIONAL ATOMIC ENERGY AGENCY

Note

1. The *Annual Report for 1993* aims to summarize only the significant achievements of the Agency during the year in question.

2. For the particular case of the chapter 'Direction and Support', the combination of managerial, budgetary and service related activities does not lend itself to an approach that exactly follows the structure of the programme and budget document.

3. All sums of money are expressed in United States dollars.

4. The designations employed and the presentation of material in this document do not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

5. The mention of names of specific companies or products (whether or not indicated as registered) does not imply any intention to infringe proprietary rights, nor should it be construed as an endorsement or recommendation on the part of the Agency.

6. The term "non-nuclear-weapon State" is used as in the Final Document of the 1968 Conference of Non-Nuclear-Weapon States (United Nations document A/7277) and in the Treaty on the Non-Proliferation of Nuclear Weapons.

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INTRODUCTION

During 1993, the major issues that were addressed by the Governing Bodies and the Secretariat of the Agency covered the entire range of the Agency's work. Particular attention was given to the development of a strengthened safeguards regime, the extension of safeguards to additional countries, initiatives taken to place material from nuclear arsenals under international supervision, and the Agency's role in implementing United Nations Security Council resolutions on Iraq. Also receiving attention were the management of plutonium and high enriched uranium, the response to the disclosure of the dumping of radioactive wastes in the Arctic seas and the Sea of Japan, the negotiations for an international convention on nuclear safety, and new measures for enhancing nuclear safety and radiation protection, particularly in the countries of the former USSR. Equally important were the further strengthening of the technology transfer programmes through the introduction of 'model projects' designed to improve the effectiveness of technical co-operation activities, the contributions made towards the implementation of the resolutions of the 1992 United Nations Conference on Environment and Development, and the introduction of improved internal management procedures, including an Agency-wide system for programme assessment and evaluation.

The Agency's activities during 1993 continued to be conducted within the framework of a zero real growth Regular Budget — the ninth year of operation under such conditions. Furthermore, the Regular Budget appropriation for Agency programmes of some $201 million was reduced by $24 million in anticipation of shortfalls in contributions. On the other hand, activities with a value of $10.5 million deferred from previous years were implemented. Total new resources available for the technical co-operation programme rose sharply to $52.9 million in 1993 from $40.3 million in 1992. This increase of 31.3% came after a decline of 17.9% in 1992 compared with 1991. Pledges to the Technical Assistance and Co-operation Fund for 1993 stood at 77.5% of the target of $55.5 million. Extrabudgetary resources, apart from those directed to technical co-operation and the ICTP, and those received from other United Nations organizations, rose by 10% to $15 million and remained vital to some programmes, notably safeguards and nuclear safety. Additional, unforeseen activities were generally accommodated within the framework of the approved programme.

This introduction highlights the activities of the Agency in addressing the changing international environment in the areas of safeguards and verification, transfer of nuclear technology, and nuclear power and safety. The main achievements within individual programmes are recorded in the programme overviews at the beginning of each chapter.

The Agency's long standing role in verifying undertakings by States to use nuclear material exclusively for peaceful purposes faced new challenges. Steps continued to be taken to strengthen the Agency's safeguards system. A re-examination of safeguards efficiency and effectiveness, started in 1992, led to the initiation of a programme of development and testing of new and alternative approaches for a strengthened and more cost effective safeguards system. Among the ideas being tested, in co-operation with a number of Member States, is the routine use of environmental sampling and analysis as a mechanism to detect clandestine nuclear activities.

The major problem in the area of safeguards implementation continued to be the Agency's inspection work in the Democratic People's Republic of Korea (DPRK). Verification activities carried out in 1992 had suggested that some nuclear material exists in the DPRK which has not been reported to the Agency. When all other efforts to clarify and resolve the issue had failed, the Director General requested the DPRK on 9 February to provide access to additional information and locations pursuant to the special inspection provisions of the DPRK's safeguards agreement with the Agency. Such access had not been granted by the end of 1993, despite repeated calls by the Board of Governors, the General Conference and the United Nations Security Council for the DPRK to extend full co-operation to the Agency. In the absence of such co-operation, the Agency was unable to verify the correctness and assess the completeness of the DPRK's initial report of its nuclear material subject to safeguards. The Agency was consequently also unable to verify the compliance of the DPRK with its obligation, under the safeguards agreement, not to divert nuclear material from peaceful use. Additionally, by the end of 1993, because of increasing lack of co-operation on the part of the DPRK, important verification measures relating to declared nuclear activities became overdue and the continuity of safeguards relevant data was damaged.

In South Africa, the world welcomed the first instance of a State abandoning its nuclear weapon capability. This gave rise to a number of important new verification tasks for the Agency. As a result of visits by Agency staff and other experts to the country, the Agency concluded by the end of 1993 that the nuclear material used for the weapons was under safeguards and that there was no indication that there remained any components of the programme that had not been either rendered useless or converted to commercial non-nuclear or peaceful nuclear uses. Work also continued towards reaching a satisfactory conclusion in relation to accounting for the production of low enriched uranium. In the context of the African continent as a whole, the Agency contributed during 1993 to preparatory work on an African nuclear-weapon-free zone — a goal which it is expected will soon be realized.

In Iraq, the Agency completed six further inspections and carried out activities to ensure the destruction or neutralization of Iraq's clandestine nuclear weapons programme. In addition, the first of two shipments of spent fuel elements from Iraq to the Russian Federation was completed during December. In the last quarter of 1993, the Government of Iraq disclosed information related to foreign suppliers of equipment, material and technical advice and also undertook to accept the obligations and to comply with the provisions of United Nations Security Council Resolution 715, which provided the formal basis for the implementation of the ongoing monitoring and verification plan. As a result of these developments, the emphasis in the work of the Agency's Action Team was directed towards preparations for the implementation of this plan.

Nuclear related matters in the countries of eastern Europe and the former USSR continued to be of international concern. The issues that were addressed in these countries included: the application of safeguards to the large nuclear programmes in some of these States; the safety of nuclear installations; the need to establish adequate infrastructures for nuclear safety and radiation protection; and the problems of radioactive contamination. The Agency helped to make significant advances during the year towards resolving such issues. Fact finding and technical missions were carried out to all major nuclear facilities in Armenia, Belarus, Kazakhstan, Kyrgyzstan, Ukraine and Uzbekistan in connection with the development of safeguards approaches, the future implementation of safeguards and the assessment *of national infrastructure requirements. In the safety area, the Agency's work concentrated on establishing priorities for safety upgradings of the various reactor types and on providing expert assistance and guidance for decisions on specific safety issues.*

In May, the Agency convened a forum in Vienna to launch a joint programme with UNDP for the provision of assistance to the newly independent States of the former USSR in strengthening their nuclear and radiation safety infrastructures. In addition, the Agency implemented a regional technical co-operation project to help these countries plan the cleanup of contaminated sites resulting from earlier activities related to the nuclear fuel cycle, defence operations and industrial and research work.

Another area attracting interest in 1993 was the increasing amounts of plutonium and high enriched uranium resulting from nuclear disarmament measures and the reprocessing of spent civilian nuclear fuel. In response to this interest, the Agency started to develop a worldwide database on separated plutonium in civilian nuclear programmes. Work also began on identifying additional confidence building measures relating to the safe handling, storage and disposal of plutonium.

Substantial progress was made in the preparation, under Agency auspices, of an international convention on nuclear safety. The convention, expected to be finalized in mid-1994, will address the safety of land-based civilian nuclear power plants and contain provisions for the peer review of safety performance. It is expected that at a later date a further convention will address the safety of radioactive waste management. Further, on the question of radiation safety, a broad-based group of international experts endorsed the new international standards for protection against ionizing radiation and the safety of radiation sources, prepared jointly by the Agency together with a number of other international organizations.

The Agency continued to contribute to the international debate on energy issues and to monitor developments in the area of nuclear power. An inter-agency project was initiated on data and methodologies for the comparative assessment of the health and environmental impacts of different means of electricity generation. Increased attention was given to improvements in nuclear power plant performance consistent with operational safety.

The outlook for nuclear energy changed little during the year. Nevertheless, many requests were received from Member States for Agency support and assistance in studies related to energy, electricity and nuclear power planning, in nuclear power feasibility studies, and in the assessment of manpower requirements. A report was published on policy planning for nuclear power, reviewing issues to be considered by governments in planning a safe, economic and reliable nuclear power programme, and a reference book was published on financing arrangements for nuclear power projects in developing countries. Attention was given to the quality of the operations management of power plants through the production of guidebooks and standards, together with the organization of advisory missions and training courses in quality management, quality culture and quality assurance.

The focus of the Agency's technical co-operation programme was sharpened with the development of the concept of model projects. A number of such projects have already been identified. These are characterized by increased responsiveness to national priorities and a greater economic or social impact for the end-user. The nuclear technology involved in each project has to be shown to be indispensable and to have distinct advantages over other technologies. Another criterion is that the local environment should be conducive to sustainable *success. The model projects identified so far include, amongst others, eradication of the fruit fly in Argentina, the industrial scale irradiation of rice in China, the establishment of a radiotherapy network in Ghana and flue gas purification in Poland.*

Consistent with United Nations system policies, Agency technology transfer activities continued to contain elements of particular relevance to women and children, notably and most directly in the area of human health. Ongoing programmes continued to focus on the study of nutrition in malnourished children and pregnant women with the aim of tailoring dietary treatment to these groups, and on the treatment of cancer in women. These programmes were supplemented in 1993 by the commencement of a project on neonatal hypothyroidism.

Many of the Agency's programmes contributed directly or indirectly to the goals of sustainable development and protection of the environment as set out in 'Agenda 21', the outcome of the 1992 United Nations Conference on Environment and Development. Of particular relevance in this context were the programmes on food and agriculture, isotope hydrology (work on both climate change and water resources) and waste management. The Agency also took an active role in inter-agency co-ordination of the implementation of Agenda 21.

An important example of the Agency's activities in relation to monitoring of the environment was the response to the concern expressed by the Contracting Parties to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention) and by the international community over the dumping of radioactive wastes in the Arctic seas — a response reflected in the Agency's involvement in the International Arctic Seas Assessment Project. Progress in this regard was made during the year, with the acquisition of basic source term information from the Government of the Russian Federation and the establishment of a programme on environmental modelling. The IAEA-MEL contributed to this assessment and participated in the 1993 Russian–Norwegian expedition to the Arctic dump sites to sample and subsequently analyse water, sediment and biota.

At a meeting of the Contracting Parties to the London Convention in November, a majority voted to prohibit totally the dumping of all types of radioactive wastes at sea. The Agency was entrusted with the practical task of providing a definition of the levels of activity below which material may be considered as non-radioactive.

The ICTP in Trieste has evolved over the years into a diversified research and teaching centre engaged in many activities that are not related to the Agency's programmes. It was therefore agreed that ICTP's interests would be best served by transferring the administrative responsibility for the Centre to UNESCO, which has a broad scientific mandate. The transfer is to be effected by a tripartite agreement between the Agency, UNESCO and the Government of Italy. The Agency will nevertheless maintain its interest in the activities of the Centre. Professor Abdus Salam, after many years of outstanding contributions to the Centre as its Director, resigned from that position and became the Rector of ICTP.

The developments described in this Introduction were managed within the framework of the Agency's approved programme and budget and demonstrate the ability of the Agency to respond flexibly, quickly and effectively to a changing international agenda. At the same time, increasing attention was paid to the possibilities for reallocating resources to emerging higher priority areas; that process is being strengthened by the introduction of an Agency-wide system of programme performance assessment. While highlighting the Agency's ability to meet emerging needs, this report also demonstrates that the Agency provided a wide range of service to Member States within the framework of its ongoing programmes.

ACTIVITIES
IN
1993

NUCLEAR POWER

Programme overview

The trend in recent years within the nuclear power industry continued in 1993 in the form of modest growth, with a few older plants being refurbished to maintain their useful life. The availability of inexpensive coal supplies and in many countries a contraction in demand for electricity have reduced demand for power plants in general, not just nuclear plants. In East Asia, however, the demand for power is growing and several countries have vigorous nuclear power programmes or are considering the implementation of a nuclear power programme. Eastern and central European countries are generally confirming their intention to continue with nuclear programmes. During 1993, nine new nuclear plants were connected to grids, while no plants were closed down. The world total of nuclear power plants in operation is 430, with a capacity of 338 GW(e). Studies have shown that nuclear power retains its economic advantage for base load electricity generation in most countries where nuclear programmes have been implemented. In the medium and longer term, demand for electricity is expected to increase substantially, particularly in developing countries striving to improve their national economies and quality of life. The increasing awareness of the potential health and environmental impacts of electricity generation systems is likely to make the nuclear option attractive in a broader range of countries. The Agency has continued to assist Member States in assessing the viability of the nuclear option and the feasibility of implementing nuclear programmes.

Because of this growing interest on the part of many developing countries and eastern and central European countries, there has been an increasing number of requests to the Agency for support and assistance in carrying out energy, electricity and nuclear power planning studies. This support has involved transfers of improved versions of the Agency's planning tools and the provision of support to technical co-operation projects.

The Agency has continued to monitor the productivity of the world's nuclear plants and to publish this information through the Power Reactor Information System database. This activity has two objectives. First to establish a base against which individual plants can evaluate their performance and second to demonstrate to the public that nuclear power plants are operating safely and reliably all around the world and making a substantial contribution to the well-being of mankind. Particular attention was paid in 1993 to the performance of WWER-440 model 230 reactors.

Recent developments have prompted a review of the support provided to operating stations in the area of training and qualification of staff. The need for skills and knowledge must nowadays be augmented by the development of sound attitudes. The aim of the Agency programme in this area is to assist Member States to become self-sufficient in training their operators, managers and technical support staff in well equipped, well staffed and well run training facilities.

In the plant life management area, the effort to understand ageing mechanisms and deterioration of performance has been extended from reactor pressure vessel embrittlement to corrosion and erosion problems of steam generators, the deterioration of important concrete structures and component obsolescence. This work embraces all aspects of reliable plant operation as it affects maintenance and repair programmes. It is co-ordinated with safety aspects of life extension and with economic studies by other international bodies.

The quality of operations management continues to be an aspect deserving attention and so the production of guidebooks and standards, together with advisory missions and training courses in quality management, quality culture and quality assurance remain a significant part of this programme. The revision of the NUSS quality assurance standards is proceeding a little more slowly than planned, owing to budget restrictions, and is now expected to be completed in 1995.

NUCLEAR POWER PLANNING AND IMPLEMENTATION

Development of an integrated package approach to energy, electricity and nuclear power programme planning

Agency methodologies (MAED, WASP, VALORAGUA and ENPEP) continued to be widely requested and used for energy, electricity and nuclear power planning. New developments include the following:

- An updated version of WASP-III, WASP-III Plus, was completed;
- Work continued on the development of an improved version of WASP, called WASP-IV, expected to be completed by 1995;
- A user's manual for an updated version of the ENPEP package was completed;
- New versions of the various models were announced and releases were made in response to requests by several Member States.

Use of computer models

	Number of releases of planning model or package			
	MAED	WASP	VALORAGUA	ENPEP
Member States	26	74	14	31
International organizations	4	10	1	5
Totals	30	84	15	36

A number of international organizations (e.g. the World Bank, the Asian Development Bank, the Inter-American Development Bank, the CEC and OLADE) have adopted the Agency's planning models for use in their Member States. Co-operative efforts initiated in 1991 with some of these organizations were completed in 1993. In particular, in the development by OLADE of a computer package for electricity expansion planning, some of the Agency's models were used and adapted to the particular needs of the Latin American Member States of OLADE.

Assistance in nuclear power programme planning

Support was given to technical co-operation projects in developing Member States, especially for nuclear power programme planning and development, including energy and nuclear power planning studies, project feasibility studies, infrastructure development planning, manpower development and project management:

- China, Colombia, Peru and Romania were assisted in carrying out planning studies using the ENPEP package with the objective of assessing the nuclear option, taking into account environmental as well as economic issues. These studies cover the following aspects for the countries mentioned: China — nuclear power economics and development plans; Colombia — energy planning with reference to the nuclear option; Peru — energy and power assessment programmes; Romania — energy demand forecasting, electricity expansion planning and nuclear programme implementation.

***Assistance in nuclear power programme planning** (cont.)*

- Assistance continued to be provided to Romania in transferring know-how on the owner's functions in project management, commissioning and the development of quality culture including safety culture.
- Assistance was provided to the Philippines in the comparative economic assessment of nuclear and fossil power plants in relation to the preparation of a long term plan for the overall power development programme.
- Assistance was provided to the Czech Republic and Slovakia, with extrabudgetary support from Spain. Since the need for and timing of the next nuclear power project is unclear after the separation of the Republics, the emphasis was shifted from the preliminary evaluation of bids to the evaluation and selection of sites for spent fuel storage and disposal, and for public information and participation.
- A report on the case study on the feasibility of small and medium power reactors in Egypt was revised for publication in 1994.
- Support continued to be provided to the National Atomic Energy Agency of Indonesia (BATAN) in reviewing the feasibility study for its first nuclear power plant on the Muria peninsula (Java) and training BATAN staff in the management, execution and review of such studies. The Education and Training Centre of BATAN was assisted in the introduction of a systematic approach to training.
- Thailand was assisted in its examination of the concerns of decision makers regarding the introduction of nuclear power into the electricity grids.
- Support was provided to the Islamic Republic of Iran in the implementation of the second one-year training course in nuclear power engineering. Assistance was also provided in strengthening the capabilities of the Atomic Energy Organization of Iran in discharging the owner's responsibilities related to the safety of nuclear power plants being considered for construction.

A draft technical document on good practices in nuclear power plant construction was circulated to Member States. Owing to budget constraints this activity could not be completed in early 1993 as originally envisaged. It will be completed in the first quarter of 1994.

Assuring and maintaining the qualification and competence of nuclear power plant personnel are essential requirements for safe, reliable and economical nuclear power. A review meeting on training for the qualification and competence of such personnel was held in February to consider recent developments and current needs of Member States. Close co-operation with the G-24 Technical Working Group on Training is maintained to identify and provide assistance on personnel training needs and priorities in the countries of central and eastern Europe and of the former USSR.

General activities

The Energy and Economic Data Bank (EEDB) was updated using the most recent information available. The new version, Micro-EEDB, will be completed in the first half of 1994. Summary information from EEDB has been published for the first time as an IAEA-TECDOC. With assistance under a contract with the Russian Federation, user friendly personal computer based software for querying the Energy and Economic Tables database was developed and will be made available to Member States upon request.

***General activities** (cont.)*

Country files have been established on nuclear power programmes in Member States and will be updated each year. Nuclear power and electricity generation projections were carried out in co-operation with other international organizations and with the assistance of consultants from Member States for publication in the Agency's Reference Data Series No. 1.

A special report entitled *Policy Planning for Nuclear Power: An Overview of the Main Issues and Requirements* was published. This document reviews, in non-technical language, political, governmental, economic, financial and technical issues that must be dealt with by a government prior to and during the commitment to a safe, economical and reliable nuclear power programme.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on electric system expansion planning (WASP)	USA	30	8 weeks
Interregional course on strengthening project management	India	29	5 weeks
National course on economic bid evaluation for nuclear power plants	China	21	2 weeks

Publications

Series and No.	Title
IAEA Yearbook 1993	Nuclear power, nuclear fuel cycle and waste management: Status and trends 1993
Reference Data Series No. 1	Energy, electricity and nuclear power estimates for the period up to 2015
Technical Reports Series No. 353	Financing arrangements for nuclear power projects in developing countries: A reference book
Special publication	Summary of a reference book on financing arrangements for nuclear power projects in developing countries
Special publication	Policy planning for nuclear power: An overview of the main issues and requirements
IAEA-TECDOC-701	Nuclear and conventional base load electricity generation cost experience
Computer Manual Series No. 5	PC-VALORAGUA (Version 1.00) user's guide

ASSESSMENT AND IMPROVEMENT OF NUCLEAR POWER PLANT PERFORMANCE

Analysis of nuclear power plant performance

The Power Reactor Information System (PRIS) database was maintained and updated. Information services continued to be provided to Member States by way of on-line access to PRIS and with the distribution of a subset of the databank, MicroPRIS, to users of personal computers. PRIS has also been redesigned and migrated to the local area network (LAN) environment with the aim of making it available on-line, improving the flexibility of data entry and reducing the complexity of information retrieval. The system is already available on a trial basis for in-house users. Access to external users is planned for 1994. Co-operation with WEC and UNIPEDE was maintained, with participation in the Committee on Performance of Thermal Plants. Work also proceeded on the promotion and harmonization of internationally compatible terminology and definitions. The organization of the country nuclear profile continued with the aim of providing Member States with an overview of the energy and economic situation for countries, forecast of nuclear energy and the main organizations and institutions playing a role in the nuclear area.

Information on PRIS

	1987	1988	1989	1990	1991	1992	1993
Participating Member States	31	31	32	32	31	34	35
PRIS on-line:							
Organizations in Member States using direct access	—	—	32	36	39	44	49
Member States using direct access	—	—	20	23	25	26	29
Direct access users	—	—	39	51	58	64	69
International organizations using direct access	—	—	1	2	3	3[a]	4[b]
MicroPRIS							
MicroPRIS subscribers	—	—	—	—	110	147	179
International organizations using MicroPRIS	—	—	—	—	3[a]	7[c]	8[d]
Member States using MicroPRIS	—	—	—	—	43	50	53
Non-Member-States using MicroPRIS	—	—	—	—	—	—	1[e]
Power reactors in operation included in the system	389	408	426	423	420	424	430
Reactor-years of experience reported (cumulative values)	3792.3	4194.3	5200	5622.9	6038.8	6479	6902
Data sets supplied on request	32	23	25	56	47	67	70

[a] OECD/NEA, WANO and WISE.

[b] ESCAP, OECD/NEA, WANO and WISE.

[c] CEC, OECD/NEA, UNSCEAR, the Uranium Institute, WANO, the WHO Regional Office for Europe and WISE.

[d] CEC, ESCAP, OECD/NEA, UNSCEAR, the Uranium Institute, WANO, the WHO Regional Office for Europe and WISE.

[e] Taiwan, China.

Nuclear power plant life management

Two technical documents on nuclear power plant life management were in preparation. Two specialists meetings on areas related to pressure retaining components and steam generators and a final meeting of a CRP on the optimization of reactor pressure vessel surveillance programmes (phase III) were held. On the basis of the results from this CRP, a database on reactor pressure vessel surveillance is being developed. Work started on a new CRP to study the problem of the life management of reactor vessel primary nozzles. The objective of this CRP is to carry out a collaborative case study and facilitate the exchange of information in the assessment of the life of reactor pressure vessel nozzles.

Quality management and quality assurance

The revision of all NUSS quality assurance (QA) documents in three packages is under way. The main purpose is to help instill a new culture into existing QA practices to achieve a rising level of excellence in nuclear power plant performance. Comments from Member States and international organizations on the Code and two Safety Guides in the first package were evaluated and resolved at an Advisory Goup meeting. The revised drafts of the five Safety Guides in the second package were completed. A new draft of a Safety Guide on QA for research and development is to be incorporated into the second package.

A technical document on nuclear power plant management problems and solutions was approved for publication in the Technical Reports Series. Three QA review and assessment missions under technical co-operation projects, emphasizing management responsibility and implementation, were carried out at Temelin (Czech Republic), Paks (Hungary) and Chashma (Pakistan).

Man–machine interface

Work continued on the revision of a guidebook on nuclear power plant instrumentation and control. The document is being prepared with a view to providing up to date information on those practices and methodologies which must be used for the design of nuclear power plant instrumentation and control (I&C) by the manufacturers of equipment and systems to meet operational and safety requirements. The first draft of a technical document on the verification and validation of software related to I&C was prepared.

The exchange of information and experience was promoted by way of three specialists meetings related to ageing, maintenance, radiation and nuclear instrumentation and modernization of I&C systems for improving nuclear power plant availability.

A joint International Electrotechnical Commission/IAEA project on instrumentation for the safe operation of water cooled graphite moderated RBMK type power reactors was started. The aim is to identify problem areas and make recommendations to improve the safety of RBMK operation through the enhancement of I&C.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Optimizing reactor pressure vessel surveillance programmes	1994	16
1992	Management of the ageing of motor operated isolating valves	1995	8
1992	Management of the ageing of reactor pressure vessel primary nozzles	1995	8
1992	Operator support systems in nuclear power plants	1995	13

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on nuclear power plant instrumentation and control	Germany	32	5 weeks
Interregional course on strengthening project management	India	29	5 weeks
National course on the universal features of management aspects of safety culture	Romania	27	1 week
National seminar on steps to nuclear power for parliamentarians	Thailand	17	1 day
National workshop for decision makers on the steps to launch a nuclear power programme	Thailand	13	2 weeks
National workshop for senior personnel assisting decision makers	Thailand	50	4 days
National workshop on a systematic approach to training	Thailand	30	2 weeks
National workshop on quality assurance as a management tool	Hungary	40	1 week
National workshop on quality assurance auditing	Czech Republic	25	1 week
National workshop on the fundamentals of nuclear power plants and the differences with conventional power plants	Thailand	30	2 weeks
Regional course on in-service inspection, techniques and systems for 440 MW WWER type reactors	Hungary	36	4 days
Regional course on WWER-440 reactor pressure vessel in-service inspection	Bulgaria	10	1 week
Regional workshop on quality management during construction and operation of nuclear power plants	Cuba	27	1 week

Publications

Series and No.	Title
Annual publication	Operating experience with nuclear power stations in Member States in 1992
Reference Data Series No. 2	Nuclear power reactors in the world
IAEA-TECDOC-685	Simulators for training nuclear power plant personnel

ADVANCED REACTOR DEVELOPMENTS

Review of general developments

Future energy needs, including possible roles for nuclear power, and the state of the art of advanced nuclear reactor systems were reviewed at a symposium hosted by the Korea Electric Power Corporation, in Seoul, the Republic of Korea, in October. The main themes of the technical sessions were design and safety objectives, impediments to and strategies for the introduction of advanced nuclear power systems, and options for international co-operation. It was generally agreed that the next generation of water cooled reactors currently under design and licensing review would, in the short and medium term, be the main contributor to any revival of nuclear power. A potential market has additionally been identified for small and medium sized nuclear reactors (SMRs). It was noted that, in the longer term, breeder reactors may also be needed, and more innovative reactors may become commercially viable and attractive. The papers and discussions demonstrated that the advanced systems designed in different countries include enhanced safety, greater simplicity and, as a basic requirement, economic competitiveness with the current generation of nuclear power plants.

Impediments to and strategies for the deployment of advanced nuclear power systems were extensively discussed at the symposium. The impediments included technical, economic and sociopolitical factors, which differ from country to country. However, some common elements were identified: insufficient public confidence, the need to demonstrate that solutions for waste disposal exist, the need for a stable and efficient licensing process and the necessity for regaining investor interest. It was underlined that greater efforts should be made to enhance public awareness of the economic and environmental advantages of nuclear power.

Several feasibility studies for the introduction of SMRs were performed or are under way. At an Advisory Group meeting in Tunisia the status and prospects for SMRs were reviewed and recommendations made for future Agency activities in this area. These include a survey of the market potential for SMRs, an in-depth review of passive safety systems and a review of integral design concepts.

In response to a request at the 1991 regular session of the General Conference, a report in the IAEA-TECDOC series has been in preparation on the development of safety principles for the design of future reactors. This builds on the earlier work of the International Nuclear Safety Advisory Group (INSAG). The final draft was agreed during an Advisory Group meeting and was reviewed by INSAG in November. Publication is scheduled for 1994.

Water cooled reactors

At its 5th meeting, the International Working Group on Advanced Technologies for Water Cooled Reactors (IWGATWR) reviewed the status and progress in advanced technology for existing and new water reactor designs, together with

Water cooled reactors (cont.)

related national technology development programmes, and formulated the scope of the Agency programme in this area. General findings included the following:

- Most countries are in a period of slow growth in demand for new electrical generating capacity. (The Republic of Korea and Japan are notable exceptions.) Coupled to this is a general decline in priority and funding levels for advanced reactor research and development.
- There is a trend towards evolutionary or near term passive advanced water cooled reactors (AWRs) based on proven technology that would not require a prototype. This trend is applicable for both advanced light water reactors and advanced heavy water reactors.
- There is an increasing emphasis by utility leadership on harmonizing requirements for future designs and implementation programmes, and on the need for greater collaboration and standardization among various utility interests.

The high degree of commonality that exists in advanced light water reactor development objectives is based, to a large extent, on the growing open exchange of information between Member States. Much of this exchange is taking place at Agency sponsored meetings and discussions. An overview of these common development objectives was given in a technical document (IAEA-TECDOC-682) published in 1993.

A Technical Committee meeting in Villigen, Switzerland, on the thermohydraulics of AWRs provided a forum for a discussion of progress in the thermohydraulics of cooling systems and boiling instability in this type of reactor.

A Technical Committee meeting in Toronto, Canada, provided participants with an opportunity to discuss recent advances in HWR technology and to report on key developments in a number of design, construction and operational areas.

Liquid metal cooled reactors

Within the framework of the International Working Group on Fast Reactors (IWGFR), the Agency utilized the services of consultants to review and discuss recent progress, to present information on major changes in fast reactor programmes and to recommend to the Agency appropriate activities in the period 1993-1995. Particular items reported at the meeting included the following:

- In Japan at the prototype Monju reactor (300 MW(e)), construction work has almost been completed and the function tests are in progress, aiming at initial criticality by early 1994.
- Design of the Prototype Fast Reactor in India is progressing.
- China has announced its intention to construct an experimental fast reactor.
- Four fast reactors are in operation in the former USSR. Under construction at two sites in the Russian Federation are BN-800 reactors with a power output of 800 MW(e).
- On the initiative of the Swiss Department of Energy and the utilities operating nuclear plants, the Paul Scherrer Institute has restarted a fast reactor research programme.
- The Prototype Fast Reactor Programme in the United Kingdom will continue to be funded by the Government until March 1994.

***Liquid metal cooled reactors** (cont.)*

- A key strategy within the advanced liquid metal reactor (ALMR) programme in the USA has been to evaluate the metal fuel cycle. The system is designed to recycle and consume its own minor actinides, and has the potential to utilize actinides generated elsewhere, e.g. in LWRs. The programme is under review.
- France is planning the following activities on liquid metal fast reactors (LMFRs): to restart the Phenix (250 MW(e)) and Superphénix (1200 MW(e)) reactors, including first priority research on Superphénix fuel for enhanced plutonium consumption and actinide burning; to develop the new LMFR project for enhanced plutonium consumption.
- Future fast reactor work in Germany (Kernforschungszentrum Karlsruhe, Siemens) will be directed towards actinide burning.
- Italy is continuing collaboration with General Electric on ALMR studies (oxide core studies, actinide burning, seismic isolation development).

A specialists meeting on the evaluation of decay heat removal (DHR) by natural convection was held at Oarai, Japan. It was reported that the experiments and the codes have produced encouraging results, showing the feasibility of DHR solely by natural convection, which is an essential 'passive safety' feature.

At a specialists meeting in France on the influence of low dose irradiation on the design criteria of fixed internals in fast breeder reactors, it was concluded that even low neutron irradiation doses have a significant effect on high and low temperature properties of some types of austenitic stainless steel. At doses above about 15 dpa (displacements per atom), the degree of embrittlement and the level of swelling in all materials tested are probably unacceptable for critical fixed reactor components.

Gas cooled reactors

At its 11th meeting, the International Working Group on Gas Cooled Reactors (IWGGCR) exchanged information on national programmes, identified areas of common interest for collaboration, and advised the Agency on its technical programme. Particular items reported at the meeting included the following:

- In China, the HTR Test Module project has been approved for construction at the Institute of Nuclear Energy Technology, Tsinghua University, Beijing. Construction is expected to begin in late 1994 and first criticality in 1998. The test module is being designed for a wide range of possible applications: electricity, steam and district heat generation; gas turbine and steam turbine combined cycle; and process heat generation for methane reforming.
- First criticality in the High Temperature Engineering Test Reactor under construction at the Oarai Research Establishment of the Japan Atomic Energy Research Institute (JAERI) is expected in 1998. The reactor will be utilized to establish basic technologies for advanced HTGRs, to demonstrate nuclear process heat applications, and to serve as an irradiation test facility for research in high temperature technologies.
- In the United Kingdom, Magnox and AGR reactors continue to supply about 20% of the electricity.
- In France, approximately 200 reactor-years of experience have been obtained with Magnox reactors. Unfortunately, the power level of this type of reactor (500 MW(e)) is not economically competitive with that of large (1000 MW(e)) PWRs. The last of the original eight Magnox reactors is scheduled to be decommissioned in 1994.

Gas cooled reactors (cont.)

Within the CRP on validation of safety related physics calculations for low enriched gas cooled reactors an international team has been assembled at the PROTEUS experimental facility of the Paul Scherrer Institute, Villigen, Switzerland. Since the initial criticality, which was achieved in July 1992, four different core configurations have been experimentally examined. Measurements have included determination of critical loadings, the worth of shutdown rods, reaction rate distributions, neutron flux distributions, the reactivity worth of water and the effect of water on control rod worth. Experience from the VHTRC critical experiments conducted by JAERI, and from the ASTRA and GROG critical experiments conducted at the Russian Scientific Centre, Kurchatov Institute, is being incorporated into this CRP.

In the framework of a CRP on validation of predictive methods for fuel and fission product behaviour in gas cooled reactors (GCRs), the status of the international database and predictive methods for fuel and fission product behaviour are being reviewed and documented. Benchmark problems for code-to-code and code-to-experiment comparisons will be defined and analysed.

The goal of a CRP on heat transport and afterheat removal for GCRs under accident conditions is to establish sufficient experimental data and validated analytical tools to confirm the predicted safe thermal response of advanced GCRs during accidents. Experimental data are being shared among the participants and benchmark problems are being analysed for code verification and validation.

A Technical Committee meeting on the response of fuel, fuel elements and GCR cores to accidental air or water ingress was convened in October at the Institute of Nuclear Energy Technology, Tsinghua University, Beijing, China. The meeting provided a forum for the exchange of information on experimental investigations, analytical predictions and means of mitigating the consequences of air or water ingress. Follow-up investigations of the Windscale accident have led to the conclusion that the accident was most probably triggered by a uranium fire resulting from the failure of one or more end caps of the aluminium cladding, exposing the uranium metal fuel to air. Experimental results of oxidation measurements were presented by JAERI, validating the predictions of the structural integrity of the HTTR core support posts. Analytical investigations of air and water ingress accidents were also reported, and it was generally concluded that the safety of GCRs is not seriously threatened by air or water ingress.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	In-core fuel management code package validation for light water reactors	1994	10
1988	Safe core management with burnable poisons in WWERs	1994	10
1989	Acoustic signal processing for the detection of boiling or sodium water reactions in liquid metal fast breeder reactors	1994	7
1989	Benchmark for in-core fuel management programs of pressurized heavy water reactors	1994	7
1990	Establishment of a thermophysical properties database for light and heavy water reactor materials	1994	6
1990	Validation of safety related physics calculations for low enriched high temperature gas cooled reactors	1995	7
1991	Intercomparison of liquid metal fast breeder reactor seismic analysis codes	1995	7

CRPs established in the current year

Subject	No. of years	Participating institutions
Design and evaluation of heat utilization systems for the high temperature engineering test reactor (HTTR)	5	4
Heat transport and afterheat removal for gas cooled reactors under accident conditions	5	7
Validation of predictive methods for fuel and fission product behaviour in gas cooled reactors	3	6

Publications

Series and No.	Title
IAEA-TECDOC-682	Objectives for the development of advanced nuclear plants
IAEA-TECDOC-687	Fission and corrosion product behaviour in liquid metal fast breeder reactors (LMFBRs)
IAEA-TECDOC-690	The status of graphite development for gas cooled reactors
IAEA-TECDOC-693	Use of fast reactors for actinide transmutation

NON-ELECTRICAL APPLICATIONS OF ADVANCED REACTORS

Co-generation and heat applications

At the request of the General Conference at its regular session in 1989, the Agency initiated activities to develop a plan for potable water production — financed partly by the Agency's Regular Budget, but with substantial extrabudgetary resources. With a view to setting the programme for 1995–1996, the following areas for consideration were established at an Advisory Group meeting:

- Need for seawater desalination,
- Steps required for seawater desalination using nuclear energy,
- Coupling of nuclear power reactors with desalination processes,
- Technical conditions for (very) small reactors, including floating plants,
- Financing models,
- Framework for a demonstration and training plant.

Activities are now focusing on the coupling of nuclear reactors with desalination processes and on feasibility studies of seawater desalination using nuclear energy. The studies are being carried out under the regular programme of technical co-operation assistance to North African countries and Saudi Arabia. In addition, information and data are being obtained on freshwater resources and potable water demand for selected subregions through contacts with other United Nations organizations.

As in 1992, the General Conference at its 1993 regular session reiterated its interest in desalination and requested Member States to provide further expert services and extrabudgetary resources in support of Agency activities in this area. The request focuses on investigations for a demonstration facility.

NUCLEAR FUSION

Fusion research and engineering

In a CRP on lifetime predictions of the first wall of fusion machines, participating institutes have compared methods for predicting the lifetime of first wall components and have compared predicted lifetimes for first wall benchmark problems with results for experiments on initially defect-free first wall components conducted at the thermal cycling facility of the Joint Research Centre of the European Union at Ispra. The evaluation of the lifetime predictions highlighted differences among the methodologies used by participating institutes for performing both 'design allowable' and 'realistic' estimates of lifetime, and resulted in recommendations of preferred methods. Ispra tests yielded lifetimes in excess of the design allowable predictions of all participants with sufficient margin. Future research plans involve performing a benchmark exercise on lifetime prediction and a companion experiment involving investigation of the influence of defects (fabrication defects, brazing defects or defects introduced by plasma disruption) on first wall lifetime under thermal cycling conditions.

A Technical Committee meeting on fusion reactor design and technology was hosted by the University of California, in Los Angeles, USA, in September. Invited papers described the status of fusion reactor design and technology programmes in China, Japan, the Russian Federation, the USA and the European Union. Also, an invited paper was presented on the design and status of the International Thermonuclear Experimental Reactor (ITER) project. The meeting provided a forum for a discussion on design and technology for several types of fusion reactors, specifically for tokamaks, stellarators, inertial confinement systems and fission–fusion hybrid systems. There was also discussion of design and technology issues beyond the objectives of ITER, for example on design and further technology needs for DEMO.

Technical Committee meetings were held on alpha particle physics (Trieste, Italy), radio-frequency launchers for plasma heating and current drive and stellarators and other helical confinement systems (Garching, Germany), pellet injection (Naka, Japan), research using small tokamaks (Serra Negra, Brazil) and H mode physics (JAERI, Japan). Summaries of these meetings will be published in the *Nuclear Fusion* journal.

The monthly ITER newsletter was published and distributed.

Nuclear Fusion *journal*

Twelve regular issues of *Nuclear Fusion* were published. Of particular importance were papers on: the isotope effect in ASDEX; the results of the first tritium experiments at JET; and the theory of ideal and resistive $M = 1$ modes in tokamaks.

Preparations for the 7th edition of the *Special Supplement to Nuclear Fusion, the World Survey of Activities in Controlled Fusion Research*, deferred in 1992, were started.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Lifetime predictions for the first wall of fusion machines	1994	5
1992	Development of software for numerical simulation and data processing and data processing in fusion energy research	1995	7

CRPs established in the current year

Subject	No. of years	Participating institutions
Development of plasma heating and diagnostic systems in institutes in developing countries using middle and small scale plasma devices	5	8

Publications

Series and No.	Title
Proceedings	Plasma physics and controlled nuclear fusion research, 1992, Vols 1–4

NUCLEAR FUEL CYCLE

Programme overview

The objectives of the nuclear fuel cycle programme are to:

- *Assist the decision making process in Member States by furnishing relevant information;*
- *Provide help in assuring the safety, reliability and economic viability, and in minimizing the environmental and health impacts of nuclear fuel cycle facilities;*
- *Help meet the needs of Member States for the safe management of spent fuel and plutonium;*
- *Assist the development in Member States of fuel with improved performance.*

In the area of raw materials for reactor fuels, efforts to complete information on uranium resources and production in eastern European countries and countries of the former USSR continued. Newly acquired information has been incorporated into Uranium Resources, Production and Demand *('Red Book') under joint preparation with the OECD/NEA. It also marked the beginning of a new arrangement whereby non-OECD member countries which are Member States of the Agency were officially invited to attend the OECD/NEA Uranium Group biennial meetings.*

In the area of reactor fuel technology and performance, the main effort was to provide a forum for the exchange of information, under the umbrella of the International Working Group on Fuel Performance and Technology (IWGFPT).

Problems associated with the increasing amounts of separated plutonium have acquired special importance. An Advisory Group meeting served as the starting point for the Agency in collecting and developing a worldwide database on separated plutonium in civilian nuclear programmes.

Work was started on identifying aspects of the safe handling and storage of plutonium for which proper documentation is either out of date or unavailable. An informal meeting on the international management of plutonium was convened in November.

Activities concerning spent fuel management, technology and safety are regarded as being of high priority and reflecting urgent needs in Member States. A set of safety documents on safe storage is expected to be completed in 1994.

New activities on the management of spent fuel from research and test reactors started during 1993. No comprehensive database on storage at research and test reactors is available and so to rectify this situation a questionnaire was sent to reactor operators; the responses received were evaluated by an Advisory Group. A number of important issues were identified and work has begun on preparation of Safety Series documents and a database.

A new subprogramme (Information on the Nuclear Fuel Cycle) was introduced during 1993. An updated version of the Nuclear Fuel Cycle Information System has been prepared, covering all fuel cycle facilities in the world. A nuclear fuel cycle and actinide database that can be used for the calculation of important parameters, such as the demand for uranium and separative work units, and plutonium and actinide generation rates, is becoming a powerful tool in estimating global trends.

A scientific programme at the regular session of the General Conference entitled the 'Back End of the Nuclear Fuel Cycle — Evaluation of its Options' provided the opportunity for a discussion of national policies on both open and closed fuel cycles.

RAW MATERIALS FOR REACTOR FUELS

Assessment of uranium resources and projection of supply and demand

The world uranium production continued to decline, following a trend that started in 1988. The 1993 uranium production is estimated to have been just over 34 000 t U, nearly 2000 t less than the previous year's production, which was 1000 t less than that estimated in the Agency's *Annual Report for 1992*. The year 1988 also marked the beginning of growing uranium imports from the former USSR and its successor States to the USA and the European Union. Six countries, namely Australia, Canada, Kazakhstan, Niger, the Russian Federation and Uzbekistan, produced nearly 67% of the world total. The 1993 worldwide reactor related requirements are estimated to be slightly over 59 000 t U, which is about 25 000 t greater than world uranium production. In other words, only about 60% of the requirements is met by current production. This declining trend in uranium production is expected to continue unless there is a significant increase in the market price.

Projected uranium demand worldwide for the period 1993–2010 can be derived from the expected development of nuclear electricity generating capacity. It is estimated that the world capacity will grow from 338.6 GW(e) in 1993 to about 446 GW(e) in 2010. This results in projected annual uranium requirements for the same period increasing from 59 000 to 75 000 t. The corresponding projection for the world uranium supply, however, is not available, as the necessary information regarding the production capabilities of important producers in Kazakhstan, the Russian Federation and Uzbekistan has not yet been made known. Considering only the former WOCA, where such information exists, uranium production capability by the year 2010 is estimated to be around 32 000 t. The balance has to be met through production from the former USSR, eastern Europe and China, where the total 1993 production was estimated at about 12 000 t. On the assumption of a stable production level in the latter group of countries, there will be unfilled requirements of about 31 000 t that will have to be met through the expansion of existing facilities and the development of new production centres. The contribution to supply from uranium reprocessing and mixed oxide (MOX) fuel is expected to remain modest up to the year 2010. The planned facilities for reprocessing uranium and fabricating MOX fuel have an annual capacity that could provide a maximum equivalent contribution of less than 5% of the projected requirements of 75 000 t U.

The preparation of the new edition of the joint Agency and OECD/NEA report *Uranium Resources, Production and Demand* ('Red Book') was completed for issue in early 1994. A total of 49 countries provided national reports on which analysis of the world's uranium supply situation has been based. The book includes, for the first time, reports from the Czech Republic, Kazakhstan, Lithuania, Mongolia, the Russian Federation, Slovakia, Ukraine and Uzbekistan, thus making this edition the most comprehensive source of information on the world's uranium resources, production and demand published to date. It will also provide supply–demand projections to the year 2010. Preparation of these projections was made difficult by the lack of a common classification of uranium resources by production cost categories, as well as incomplete information from the countries of the former USSR. Efforts will be made to find solutions to this problem during the next two years.

Management of uranium exploration, deposit development, production and closure

Terms of reference and information for peer reviews by teams of international experts of the operational safety of uranium mining and milling facilities were prepared by consultants. The reviews are intended to provide a technical exchange of experience and practice at the working level and are aimed at strengthening the safety programmes, procedures and practices of the facilities visited.

In view of the growing importance of the in situ leaching method in uranium production, preparation began on a comprehensive report covering the detailed technology as practised in the USA, where carbonate leaching systems are used, and the countries of eastern Europe and the former USSR, where leaching by sulphuric acid is the common practice.

A comprehensive report on state of the art uranium extraction technology formed the subject of a Technical Reports Series publication. This report represents an update and expansion of an earlier joint OECD/NEA and Agency report issued in 1983. It was also meant to preserve the technology and operating 'know-how' developed during the past decade. Relatively little of this experience has been documented because technical personnel have moved to other industries as uranium mines and mills have been closed. The publication is expected to become an important reference source.

Preservation of uranium geology and exploration data and maintenance of databases

The preparation of a world atlas of uranium deposits was initially hampered by the lack of a suitable digital geological map on which information could be plotted. However, a map produced by the Geological Survey of Canada has proved suitable and a tentative arrangement has been made to produce the map under contract before the end of 1994. The publication of such an atlas is considered timely since information previously not available from the former USSR, eastern Europe and China can now be incorporated. The atlas is viewed as an important contribution to the understanding of the world uranium supply.

Case histories and recent developments in the use of uranium exploration data and techniques in environmental studies were the subject of a Technical Committee meeting. The technical papers presented related mainly to experience in North America and Europe. They reported the growing importance of airborne and vehicle-borne gamma ray spectrometry in mapping natural radioactivity and as primary tools in emergency response actions. The proceedings will be issued as an IAEA-TECDOC in 1994.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on computerized databases in mineral exploration and development, for uranium in particular	Zambia	17	3 weeks
Regional course on spatial data integration for uranium exploration, resource assessment and environmental studies	China	18	3 weeks

Publications

Series and No.	Title
Technical Reports Series No. 341	Analytical techniques in uranium exploration and ore processing
IAEA-TECDOC-720	Uranium in situ leaching

REACTOR FUEL TECHNOLOGY AND PERFORMANCE

Reactor fuel materials

A CRP on burnable absorbers for LWR fuels (1990–1993) was completed with a final Research Co-ordination meeting in Çekmece, Turkey. A report will be published as an IAEA-TECDOC. The main conclusion from the CRP is that the use of burnable absorber fuel is a well established technology as a result of over twenty years of commercial utilization in BWRs. Gadolinium has emerged as the most widely used burnable absorber. Burnable absorber fuels are utilized, or are being considered for utilization, in all BWRs, in most PWRs, and more recently in WWERs. The final report on gadolinium fuel illustrates the fuel properties, manufacturing techniques, design approaches, utilization performance and potential impacts on the back end of the fuel cycle.

Preparation for a new CRP on stress corrosion cracking in zirconium alloys has begun. Appropriate samples in the form of sheets of zircaloy have been obtained from the USA and France, and standard fuel cladding tubes of Zr-1% Nb have been obtained from the Russian Federation. Preparatory experiments with these samples have begun in the host laboratory, AEA Industrial Technology, Risley, United Kingdom. The CRP will be supervised by a group of experts from France, the Russian Federation and the United Kingdom. Its objectives are to gain more insight into the fundamental mechanisms of stress corrosion cracking and to provide a means for transferring technological know-how in this experimental field from the host laboratory and supervisory group to the participating institutes in developing Member States.

Water reactor fuel performance and technology

Water chemistry plays an important role in attaining optimum performance in power plants. Corrosion control and activity buildup depend upon the physicochemical parameters of the coolant. As shown during the last CRP on water chemistry control and coolant interaction with fuel and primary circuit materials in water cooled power reactors (WACOLIN), knowledge in corrosion control and activity buildup through chemistry control has progressed over recent years. However, although sensitive parameters are known, their control in a complicated machine such as a reactor is a difficult task. It was recommended at the end of WACOLIN that a new CRP be undertaken on high temperature on-line monitoring of water chemistry and corrosion related to fuel behaviour and activity transport. In October 1993, after confirmation by the International Working Group on Water Reactor Fuel Performance and Technology (IWGFPT), consultants were utilized to establish the CRP.

A CRP on fuel modelling at extended burnup (FUMEX) started in 1993 with a blind exercise carried out on the basis of six experiments irradiated in the Halden reactor. Thirteen countries and one international organization are taking part in the CRP and fifteen computer codes have been involved in the exercise. Participants should finalize results of their calculations by February 1994; the calculations will then be compared with experimental results. In the second part of the CRP, elementary models will be reviewed in the light of results obtained and recommendations for further improvement will be issued.

***Water reactor fuel performance and technology** (cont.)*

A Technical Committee meeting on the influence of water chemistry on fuel cladding behaviour was hosted in Řež by the Czech Republic in October. Significant advances have taken place in recent years and information on the monitoring of water chemistry and on potassium water chemistries in Russian reactors were discussed for the first time. The purpose of the meeting was to: review cladding corrosion and hydrating with increasing burnup; examine the status of studies contributing to the mechanistic understanding of these phenomena and their modelling; analyse progress made in the on-line observation of water chemistry parameters in both material testing reactors and power reactors; and explore the approaches to the balancing of these adverse effects, especially in the area of alternative water chemistry and improved cladding materials.

Advanced fuel technology and performance

At a Technical Committee meeting on advances in control materials for water reactors, materials used in control rod assemblies in PWR, BWR, RBMK, WWER-440, WWER-1000 and CANDU reactors were identified as well as areas where their performance could be improved. Improved materials under development for advanced water reactors were discussed. In addition, the meeting addressed the problems of interim storage of control rod assemblies. The proceedings of the meeting are being prepared for publication in 1994 as an IAEA-TECDOC.

Plutonium accumulation and emerging problems

Data were collected at an Advisory Group meeting to validate the Agency's inventory estimates and projection methodology for quantities of separated plutonium in civilian nuclear power programmes. The data on present inventories confirmed the Agency figures, but the data collected on projected separation and use rates for plutonium provided a new benchmark. The validity of the Agency's methodology was confirmed.

A Technical Committee meeting was held in Vienna to consider issues related to the safe handling, transportation and storage of separated plutonium in civilian nuclear power programmes. The meeting showed that the level of safety is high but identified deficiencies in worldwide information exchange and documentation which may require the continuation of activities in this programme area.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1990	Burnable absorber for LWR fuel (BAF)	1994	9
1992	Examination and documentation methodology for water reactor fuel (ED-WARF-II)	1996	13

CRPs established in the current year

Subject	No. of years	Participating institutions
Fuel modelling at extended burnup (FUMEX)	4	16

Publications

Series and No.	Title
Technical Reports Series No. 347	Coolant technology of water cooled reactors: An overview
IAEA-TECDOC-684	Corrosion of zirconium alloys in nuclear power plants
IAEA-TECDOC-692	Poolside inspection, repair and reconstitution of LWR fuel elements
IAEA-TECDOC-697	Fission gas release and fuel rod chemistry related to extended burnup
IAEA-TECDOC-699	Impact of extended burnup on the nuclear fuel cycle
IAEA-TECDOC-706	Behaviour of core materials and fission product release in accident conditions in LWRs
IAEA-TECDOC-709	Fuel failure in normal operation of water reactors: Experience, mechanisms and management

SPENT FUEL MANAGEMENT, TECHNOLOGY AND SAFETY

Spent nuclear fuel arisings, storage options and practices

At an Advisory Group meeting on spent fuel management, participants reported on the updated status of spent fuel management programmes in their respective countries. A common feature of most national situations, independent of the fuel cycle back end options, is the ongoing need for additional storage. The review showed that spent fuel management is a maturing and safe technology. The Regular Advisory Group reviewed the draft of the Agency's programme on spent fuel management for 1995–1996.

Experts from Canada, the Russian Federation, the United Kingdom and the USA prepared the final draft of a technical document on a spent fuel management database. This publication will provide specialists with information on a minimum set of data parameters to support safe spent fuel management operations.

During a Technical Committee meeting on away-from-reactor (AFR) storage concepts and their implementation, participants exchanged information on the experience and prospects of design, construction and operation of AFR storage and defined the most important areas for future activity. Four issues were considered: the current status of AFR, AFR technology evaluation and selection criteria, anticipated future developments and possible initiatives of the Agency in the area of AFR storage of spent fuel. The proceedings of the meeting will be prepared for publication as an IAEA-TECDOC.

Safety of spent fuel storage

At the request of the Hungarian Atomic Energy Commission, an expert team, within the framework of the Irradiated Fuel Management Service Programme (IFMAP), visited Hungary to advise the Nuclear Safety Inspectorate and the Paks Nuclear Power Plant operators on the safety of spent fuel storage. The experts discussed the requirements for a pre-construction safety analysis report and provided information about the international and national requirements in licensing different spent fuel storage systems, the regulatory system in different countries, and various technical details. Hungary elected to construct an AFR spent fuel storage facility using modular dry vault technology.

Handling and storage of spent fuel from research and test reactors

An Advisory Group meeting on storage experience with fuel from research reactors was held with the objective of obtaining a perspective on the origins, amounts and types of spent fuel stored at research reactors worldwide. Country reports underlined the trend to store research reactor fuel for longer and longer times in wet interim storage.

Technical developments in the back end of the nuclear fuel cycle

At a Technical Committee meeting on safety and environmental aspects of partitioning and transmutation (P&T) of actinides and fission products, it was noted that there is considerable interest among Member States and international organizations in the P&T option as a potential complement to the reference concepts of the closed nuclear fuel cycle. The purpose of P&T is to reduce the long term effects of radiotoxicity of actinides and long lived fission products in a geological repository, but it cannot eliminate the need for a geological repository. The specific role of P&T in the nuclear fuel cycle needs to be further defined within the general trend to minimize wastes and the concern about a maximum degree of safety in the very long term.

***Technical developments in the back end of the nuclear fuel cycle** (cont.)*

A CRP on irradiation enhanced degradation of materials in spent fuel storage facilities was started. The objective is to investigate materials behaviour in both wet and dry storage facilities, and more specifically to construct a quantitative database for predicting the viability of extending the storage of the materials in question over several more decades. The first Research Co-ordination meeting took place in Vienna. The participants agreed on the details of the experimental programme to maximize the input to the database.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1991	Behaviour of spent fuel assemblies and storage equipment under long term storage conditions (BEFAST III)	1995	15

CRPs established in the current year

Subject	No. of years	Participating institutions
Irradiation enhanced degradation of materials in spent fuel storage facilities	4	6

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on the storage of spent fuel from nuclear power plants and research reactors	France	25	3 weeks

Publications

Series and No.	Title
Technical Reports Series No. 356	Feasibility of separation and utilization of caesium and strontium from high level liquid waste
Special publication	Irradiated fuel management advisory programme (IFMAP)
IAEA-TECDOC-686	Improvements in materials reliability in the back end of the nuclear fuel cycle
Newsletter	Spent fuel management newsletter

INFORMATION ON THE NUCLEAR FUEL CYCLE

Nuclear fuel cycle databases

The Nuclear Fuel Cycle Information System database (NFCIS) was updated. A draft document providing information on 448 civilian nuclear fuel cycle facilities in 43 countries was prepared. The document was sent for review to the pertinent Member States and organizations. The document will be submitted for publication in 1994.

Development work continued on the nuclear fuel cycle and actinide database (the CYBA code) that can calculate actinide inventories and fuel cycle related data such as spent fuel arisings, fuel fabrication requirements, enrichment services and natural uranium needs from the known electricity generation outputs of power reactors. A meeting was held to finalize the input data, gather the necessary material for a benchmark and define a clear procedure for actinide calculation. The final results of this work will be published in 1994 in two parts: fuel cycle balance and actinide calculations.

RADIOACTIVE WASTE MANAGEMENT

Programme overview

While experts believe that radioactive wastes can be handled and disposed of in an appropriately safe manner, there is an increasing trend by Member States to request more international guidance and co-ordination in this field. In responding to this need, the Agency's radioactive waste management programme focused on several key activities during 1993, including the development and promulgation of Radioactive Waste Safety Standards (RADWASS), the building and strengthening of waste management infrastructures, the development of radiological and safety criteria for waste disposal and the co-ordination of international radiological/environmental assessment projects. During the period, the implementation strategy of the programme was shifted to providing, where appropriate, more direct assistance to Member States by offering basic design packages for the safe handling, processing and storage of radioactive wastes generated from nuclear application technologies. Particular attention was given to promulgating to developing Member States a basic reference design package for a facility to safely receive, handle, process and store spent radiation sources.

Other areas receiving major emphasis included advisory service missions, guidance on the safety and technical aspects of decommissioning nuclear facilities, quality assurance management for waste packaging and disposal systems, safety assessment in near surface disposal facilities and the environmental restoration of contaminated land masses.

The RADWASS programme continues to be the foundation block of the Agency's waste management programme. The International Radioactive Waste Management Advisory Committee (INWAC) in March 1993 approved the full scope programme, which now includes 55 documents comprising 1 Safety Fundamentals, 6 Safety Standards, 28 Safety Guides and 20 Safety Practices. The programme will be completed by the year 2001. The importance of RADWASS to Member States was reaffirmed during the 1993 General Conference by a resolution which requested the Agency to maintain emphasis in the field of radioactive waste management "especially with regard to RADWASS". It is expected that the Safety Fundamentals document will be presented to the Board of Governors for approval in 1994.

The strengthening of waste management infrastructures in Member States which generate wastes from nuclear applications activities received firm support from INWAC during its March 1993 meeting. INWAC recommended that the Agency link technical assistance involving nuclear materials with the requirement that a national waste management programme be planned or established. To strengthen waste management infrastructures, the Agency offers advisory missions under the Radioactive Waste Management Advisory Programme (WAMAP). During 1993, two WAMAP missions were undertaken and a follow-up mission was conducted to evaluate progress made in implementing previous WAMAP recommendations. New initiatives were started in 1993 in co-operation with UNDP to develop projects in developing Member States as a response to 'Agenda 21' from the 1992 United Nations Conference on Environment and Development. Projects to enhance safety and provide for the sound environmental management of radioactive wastes have been developed for four pilot countries in various geographical regions. The projects are now under review by UNDP. Emphasis is also being placed on building waste management infrastructures in the newly established States of the former USSR. Specific projects are being developed for UNDP funding support after fact-finding missions have been carried out.

With the political changes in eastern Europe and the former USSR, information has become available which has revealed the existence of many environmental problems connected with past waste management practices, improper handling of uranium mine and mill tailings and insufficient controls on radionuclide releases to the environment. These practices have led to the existence of large contaminated land masses in eastern Europe which may require cleanup and/or stabilization.

In 1993, the Agency initiated a regional assistance project on environmental restoration in central and eastern Europe. The project will provide assistance to Member States in the areas of identification of contaminated sites and the assessment of risks/environmental hazards posed by those sites and foster the exchange of technology and information on site cleanup processes. The first workshop under this project was held in Budapest in October and focused on the identification and radiological characterization of contaminated sites. Further workshops are scheduled to take place in 1994 on detailed planning methods and technologies available for the restoration of contaminated sites.

The Agency's role as the focal organization for developing criteria for waste disposal and co-ordinating international assessment work on the environmental and radiological impacts of waste disposal continued in 1993. Through the operation of the INWAC Subgroup on Principles/Criteria for Waste Disposal, efforts are being made to reach a consensus on a series of contentious waste disposal issues (for example, the time periods to be covered by safety assessments, the use of indicators for evaluating repository safety, and the interface between safeguards requirements and the operation and closure of deep geological repositories).

The Agency is the competent international body on matters related to radioactivity to the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention 1972). In the November 1993 meeting of the Contracting Parties to the London Convention, a majority of the Parties voted to totally prohibit the dumping of all types of radioactive wastes at sea. The Agency has been requested by the Contracting Parties to provide a definition of the levels of radioactivity below which material may be considered as 'non-radioactive'.

In response to concern expressed by the Contracting Parties to the Convention and the international community over high level radioactive waste dumping in the Arctic seas, the Agency started the International Arctic Seas Assessment Project (IASAP) in 1992 and began implementation of the programme in 1993. IASAP has been organized as an international assessment project to evaluate the health and environmental risks posed by the wastes that have been dumped and to evaluate the need for, and feasibility of, possible remedial actions. Tangible progress has been made on the project, with the acquisition of basic source term information from the Government of the Russian Federation and the establishment of a CRP on environmental modelling in the Arctic seas. The Marine Environment Laboratory (IAEA-MEL) is contributing to this assessment by offering assistance in analytical quality assurance, radioactivity monitoring, computer based dispersion modelling, radiological assessment and database provision. The IAEA-MEL participated in the 1993 Russian–Norwegian expedition to the Arctic dump sites to sample and subsequently analyse water, sediment and biota in the region.

Unplanned activities (international peer reviews of the national waste management programmes of Finland and the Czech Republic, fact-finding missions to countries of the former USSR and the development of a regional model technical assistance project on waste management infrastructures) and shortfalls in the availability of resources originally budgeted for the programme resulted in the deferment or cancellation of some tasks in the areas of waste disposal and exemption principles.

The IAEA-MEL carried out a programme of analytical quality control services (AQCS) for analysis of marine radioactivity. More than 150 Member State institutions are now associated with this AQCS programme.

The IAEA-MEL also joined the Agency's Emergency Response System and began an assessment of the feasibility of its involvement in an expanded environmental monitoring programme in which waste effluents may provide useful isotopic signals in the marine and aquatic environment. The laboratory also organized four CRPs, including those on radioactivity in the Black Sea and on sources of marine radioactivity and associated dose assessment. It participated in many international programmes in which nuclear and isotopic techniques provided information on the marine environment, including carbon flux (greenhouse effect), water movement, radionuclide bioconcentration and marine contaminant behaviour.

HANDLING, TREATMENT, CONDITIONING AND STORAGE OF RADIOACTIVE WASTES

Advanced technologies for the processing of radioactive wastes from the nuclear fuel cycle

The potential of new processes, such as reverse osmosis, ultrafiltration, high gradient magnetic separation and electro-osmosis, has been explored in many Member States with the aim of improving the efficiency of radionuclide removal from liquid radioactive streams. A Technical Reports Series document being developed reviews the status of new technologies, emphasizing their applications to large scale operations. The report was prepared in 1993 and is ready to be submitted for publication.

Support for the safe management of spent radiation sources in developing countries

A standardized design for a conditioning and interim storage facility for spent radiation sources has been prepared. The design package provides information on facility layout options for different climates as well as operating procedures, a generic safety assessment and a model quality system manual for the preparation of waste packages. The package has been developed to allow Member States to proceed directly into the construction of a facility for the safe handling, processing and storage of spent radiation sources.

A technical document on methods to identify and locate spent radiation sources was completed and will be ready for publication in the IAEA-TECDOC series in 1994.

The first phase of development of a computerized database for tracking radiation sources up to the point of final disposal is being completed. A limited test version of the program was available by the end of 1993 and was demonstrated at a regional training course held in Greece on the management of spent radiation sources. A programme for field application of the computerized database is scheduled to start in 1994 in selected Member States. Successful operation of this database will assist Member States in the management of radiation sources and reduce the risk of sources being lost or removed from proper radiation protection controls.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1991	Performance of high level waste forms and packages under repository conditions	1995	13
1991	Treatment technologies for low and intermediate level wastes generated from nuclear applications	1995	12
1992	Waste treatment and immobilization technologies involving inorganic sorbents	1996	14

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on the management of radioactive wastes from nuclear power plants	USA/Canada	25	4 weeks
Regional course on the management of spent radiation sources	Greece	25	3 weeks
Regional course on the storage and disposal of spent radiation sources and solid wastes	Kenya	19	2 weeks

Publications

Series and No.	Title
Technical Reports Series No. 350	Improved cement solidification of low and intermediate level radioactive wastes
Technical Reports Series No. 352	Bituminization processes to condition radioactive wastes
Technical Reports Series No. 355	Containers for packaging of solid and intermediate level radioactive wastes
Technical Reports Series No. 358	Off-gas and air cleaning systems for accident conditions in nuclear power plants
IAEA-TECDOC-689	Treatment and conditioning of spent ion exchange resins from research reactors, precipitation sludges and other radioactive concentrates
IAEA-TECDOC-705	Radioactive waste management at WWER type reactors

RADIOACTIVE WASTE DISPOSAL

Technologies for near surface disposal systems for low and intermediate level radioactive wastes

A technical report on the siting of near surface radioactive waste disposal facilities for countries producing small volumes of radioactive wastes was completed and submitted for publication. Practical guidance on the procedures and guidelines for identifying and evaluating suitable near surface disposal sites are given in the report by specifying technical approaches, taking into account the requirements to satisfy siting criteria, the level of technical detail and the relationship of various activities involved in each stage of the siting process. Information on public involvement and on the experience of some Member States in the siting of their near surface radioactive waste disposal facilities is also given.

In the framework of a CRP on the performance of engineered barrier materials in near surface disposal facilities, a Research Co-ordination meeting was held in which research achievements regarding physicochemical properties and the long term durability of the materials were presented and discussed.

Technologies for deep geological disposal systems for high level radioactive wastes

The preparation of a technical report on hydrogeological investigations of sites for the geological disposal of radioactive wastes was initiated in 1993. Issues that will be addressed in the report are: the experience gained in this matter in Member States, the characterization of the hydrogeological system for the various geological host rock types, and a description of the disposal system, essentially from the perspective of the hydrogeology, stability and dynamic processes involved.

In assessing the long term performance of waste isolation systems, a key question that arises is how repository developers and performance assessors can make, with confidence, long term predictions on the basis of short term laboratory and field studies. To address this issue, a CRP was initiated on the extrapolation of short term observations to time periods for isolation of long lived radioactive wastes. The scientific background and scope, objectives and implementation schedule were elaborated.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1991	Performance of engineered barrier materials in near surface disposal facilities	1995	14

CRPs established in the current year

Subject	No. of years	Participating institutions
Extrapolation of short term observations to time periods for isolation of long lived radioactive wastes	4	8

Publications

Series and No.	Title
Proceedings Series	Geological disposal of spent fuel, high level and alpha bearing radioactive waste
Technical Reports Series No. 349	Report on radioactive waste disposal

DECONTAMINATION AND DECOMMISSIONING OF NUCLEAR INSTALLATIONS

Development of decontamination and decommissioning technology

A technical report on the long term storage of shut down nuclear installations was started in 1993 and is at an advanced stage of preparation. Sufficient experience is now available worldwide on nuclear installations, in particular nuclear power plants, which have reached a condition of safe storage and are bound to remain in that condition for extended periods of time. The report aims at establishing conditions and safety requirements for nuclear installations being left dormant until final dismantling takes place. Another technical report on the design and construction of nuclear power plants to facilitate decommissioning was started during the year. The report considers how design/construction rules and practices for power reactors have evolved to meet decommissioning requirements.

A technical report on decommissioning techniques for research reactors was started in 1993 and will be submitted for publication in 1994. The technical experience which had been gained until a few years ago related in general to individual reports on first-of-its-kind projects. As the number of decommissioning projects has increased, considerable additional experience has been gained so that general conclusions on decommissioning techniques for different types of research reactors can now be drawn. This document collects, reviews and presents this information to complement existing literature and assist Member States in achieving cost-effective and safe decommissioning of their research reactors.

As a result of recent changes in central and eastern Europe, details of environmental conditions are being revealed. In many areas, the preservation and protection of the environment were previously neglected. The radioactive materials resulting from diverse activities in the nuclear fuel cycle, defence related operations, various industries and medical and research facilities have left a large number of contaminated sites. The Agency has now launched a technical co-operation regional project on environmental restoration. The project was initiated in the latter part of 1992 and is scheduled to end by 1994. Twelve countries from the region participated in the first phase of the project. The project is comprised of three workshops addressing the following sequential themes:

- Identification and radiological characterization of contaminated sites,
- Planning for environmental restoration,
- Technologies for environmental restoration.

The first workshop under this programme was held in October. An IAEA-TECDOC will be published on completion of the project.

A technical report was approved for publication on the factors relevant to decommissioning uranium mining and milling facilities and managing the wastes from such operations.

Preparation of a guidebook was initiated on the methodology for assessing the long term environmental impact of uranium mining/milling facilities.

Series and No.	Title
Technical Reports Series No. 348	Application of remotely operated handling equipment in the decommissioning of nuclear facilities
Technical Reports Series No. 351	Planning and management for the decommissioning of research reactors and other small nuclear facilities
IAEA-TECDOC-714	National policies and regulations for decommissioning nuclear facilities
IAEA-TECDOC-716	Decontamination and decommissioning of nuclear facilities: Results of a Co-ordinated Research Programme, Phase II: 1989–1993

Publications

RADIOLOGICAL AND ENVIRONMENTAL ASPECTS OF WASTE MANAGEMENT

Development of safety criteria for radioactive waste repositories

Since the process of planning for the disposal of radioactive wastes raises a number of unique problems due mainly to the very long time-scales which have to be considered for some of the wastes, a special forum was established in 1991 for the discussion and resolution of these issues. To date, the forum, known as the INWAC Sub-Group on Principles and Criteria for Radioactive Waste Disposal, has tackled a number of issues: the time periods into the future for which it is necessary to perform safety assessments, in view of the fact that some radioactive wastes will still be hazardous after one million years; the nature of the indicators of safety which should be used at different times in the future; the interface between the requirements of nuclear safeguards and those of radioactive waste management, especially for repositories containing spent fuel; and the actions required in the post-closure phase of a repository, including consideration of the need to monitor the environment and for schemes to reduce the risk of accidental intrusion into the repository. While the answers to many of the questions are still open to debate, tangible progress in reaching consensus between leading specialists in the field has been made on several issues in 1993 and the first report of the Sub-Group will be issued in 1994.

Environmental studies in relation to marine disposal

Since 1974, the Agency has fulfilled the role of the competent international body on matters related to radioactivity to the Convention on Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention 1972). During this time the Agency has developed and kept under review its definition of high level wastes unsuitable for dumping at sea and its recommendations to national authorities on the issuance of special permits for the dumping of low level wastes. A voluntary moratorium on low level radioactive waste dumping was introduced in 1983 and extended in 1985 pending the final report of the Inter-Governmental Panel of Experts on Radioactive Waste Disposal at Sea (IGPRAD). The Agency has provided the bulk of the scientific input to IGPRAD through the publication of technical reports. The work of IGPRAD was finalized in mid-1993 and its report was considered at the 16th meeting of Contracting Parties to the London Convention in November 1993. At that meeting, a decision was taken, by qualified majority, to totally prohibit the dumping of all types of radioactive wastes at sea. In relation to this decision the Agency has been requested to provide a definition of the levels of radioactivity below which material may be considered 'non-radioactive' in the context of the Convention.

In addition to its formal role, the Agency supports the London Convention through various other activities. In response to the concern expressed by Contracting Parties in 1992 over the disclosures of high level radioactive waste dumping in the Arctic seas, the Agency instituted the International Arctic Seas Assessment Project (IASAP) to evaluate the health and environmental risks posed by the dumped wastes and to evaluate the feasibility of possible remedial actions. Progress has been made during 1993 with the acquisition of basic source term information from the Government of the Russian Federation and the establishment of a CRP on environmental modelling in the Arctic seas area. The assessment is supported by programmes of investigation in the Arctic seas area organized principally by the Governments of Norway and the Russian

***Environmental studies in relation to marine disposal** (cont.)*

Federation. The IAEA-MEL participated in the Norwegian–Russian exploratory cruise to the Kara Sea to sample and subsequently analyse sea water and sediment samples, and organized analytical laboratory control exercises for the participating Norwegian and Russian laboratories. In view of the political sensitivity of the subject in many countries, the IASAP aims to produce a demonstrably independent and objective assessment of the situation through the involvement of leading international laboratories and scientists. In a separate but related activity, an inventory of radioactive material entering the marine environment is being developed and maintained. The information obtained during 1993 on radioactive waste dumping by the former USSR and the Russian Federation in the Arctic seas and in the northwest Pacific Ocean has required updating of the previous publication on this subject, IAEA-TECDOC-588. A revised version will appear in 1994.

Support for marine radioactivity monitoring

The IAEA-MEL provides analytical quality control services to over 150 Member State institutions. During 1993, two reports on intercomparison exercises were issued and two new sediment samples were distributed. The laboratory also continued its association with the Helsinki Commission's Group of Experts on Monitoring of Radioactive Substances in the Baltic Sea; three specific intercomparison exercises on sediment samples were organized. The yearly intercomparison exercise on sea water is continuing.

Work continued on the development of the Global Marine Radioactivity Database (GLOMARD) project, for which the IAEA-MEL is acting as a central facility for the collection and synthesis of data on radioactivity in the world's oceans and seas. The database will provide information on the levels of radioactivity in sea water, sediments and biota.

The IAEA-MEL continued the development of modern, sensitive and cost effective methods of radioactivity monitoring and emergency response, including in situ underwater and sea-bed gamma spectrometry and aerial gamma spectrometry. Another approach involves further development of high sensitivity radiometric techniques permitting the measurement of microbecquerel quantities of radionuclides in the environment; this may also be of importance for environmental monitoring for safeguards purposes.

A CRP on sources of radioactivity in the marine environment and their relative contributions to overall dose assessment from marine radioactivity was completed and for the first time dose rates based on ^{137}Cs and ^{210}Po in sea water and fish have been estimated for the world population.

Research on radionuclides in the marine environment

The IAEA-MEL continued its work on the application of nuclear and isotopic techniques to study marine carbon fluxes, by participation in oceanographic cruises in the Mediterranean and Adriatic Seas. The Mediterranean time-series study was carried out within the framework of the International Joint Global Ocean Flux Studies (JGOFS) Programme. Shorter surveys off the Rhone and Po rivers were also made to examine the importance of river outflow on offshore fluxes of particulate carbon and associated elements and radionuclides.

A double radiotracer technique has been developed for studying the marine cycling of the natural radionuclide ^{210}Po. Preliminary studies have demonstrated that the high ^{210}Po concentrations typically measured in marine crustaceans and fish are almost entirely due to food-chain transfer. This finding has major implications for the comparative assessment of radiological inputs from nuclear and non-nuclear industries.

Research on radionuclides in the marine environment (cont.)

Experimental efforts continued towards an improved understanding of the biogeochemical behaviour and transfer of radionuclides in order to refine multitracer gamma spectrometric techniques for simultaneously measuring turnover rates of radionuclides and analogue elements in marine organisms and various detrital particles. These experiments facilitate the interpretation of results from radionuclide monitoring studies that employ bioindicator organisms to furnish information on levels of radioactivity in nearshore environments.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Sources of radioactivity in the marine environment and their relative contributions to overall dose assessment from marine radioactivity	1993	17
1988	Validation of models for the transfer of radionuclides in terrestrial, urban and aquatic environments (VAMP)	1994	60
1990	Safety assessment of near surface radioactive waste disposal facilities (NSARS)	1995	17

CRPs established in the current year

Subject	No. of years	Participating institutions
Application of tracer techniques in the study of the Black Sea	3	13
Modelling of the radiological impact of waste dumping in the Arctic seas (part of IASAP)	4	7

Publications

Series and No.	Title
Special publication	Validation of environmental model predictions (VAMP)
IAEA-TECDOC-725	Risk comparisons relevant to sea disposal of low level radioactive waste

WASTE MANAGEMENT PLANNING AND INFRASTRUCTURE

Radioactive waste safety standards (RADWASS)

The Radioactive Waste Safety Standards (RADWASS) programme was reviewed as scheduled by the International Radioactive Waste Management Advisory Committee (INWAC) in early 1993. INWAC approved the addition of further documents, in particular Safety Practices, to the RADWASS publication plan. The programme now includes 55 documents, comprising 1 Safety Fundamentals, 6 Safety Standards, 28 Safety Guides and 20 Safety Practices and is to be accomplished in three phases, i.e. Phase I (1991-1994) with 12 documents, Phase II (1995-1998) with 23 documents and Phase III (beyond 1998) with the remaining 20 documents.

Agreement was reached in 1993 by experts on the number and content of safety principles to be included in the Safety Fundamentals document. This document will be submitted to the Board of Governors for approval in 1994.

Direct assistance and support for national waste management programmes

The change in emphasis on the Waste Management Advisory Programme (WAMAP) towards more follow-up and direct assistance initiated in 1992 has continued. Two regular WAMAP missions were conducted in 1993. In addition, a formal follow-up mission was arranged. The result of this will be used in the development of a more general follow-up plan.

International peer reviews of the national waste management programmes of Finland and the Czech Republic were conducted as part of the Agency's Waste Management Assessment and Technical Review Programme (WATRP). The report of the WATRP experts was provided to the Finnish Government in November. The WATRP report on the Czech review, which covered the development of a deep geological repository, will be forwarded to the Government of the Czech Republic in 1994.

In response to 'Agenda 21' of the 1992 United Nations Conference on Environment and Development, which includes a chapter on the safe and environmentally sound management of radioactive wastes, a series of four national waste management projects with significant impact on the protection of the environment have been developed together with the respective countries. The projects are under consideration for funding through a special UNDP account.

The radiation protection and waste management situation in the newly established states of the former USSR was discussed at a forum in Vienna jointly organized by the Agency and UNDP. On the basis of the results of the forum and of follow-up fact-finding missions, a programme for assistance is under development.

COMPARATIVE ASSESSMENT OF NUCLEAR POWER AND OTHER ENERGY SOURCES

Programme overview

The awareness of the potential health and environmental impacts of different energy and electricity systems is increasing at the local, national and international levels. In many Member States there is a need to plan, design and implement electricity supply strategies adapted to meeting the growing demand at low cost, as well as to the objective of minimizing the impacts on human health and the environment. Therefore, there is increasing interest in the development, adaptation and application of databases and tools for the comparative assessment of different electricity generation options, incorporating health and environmental aspects as well as technical and economic performance indicators.

In response to this interest, the Agency has pursued its activities on the comparative assessment of nuclear power and other energy sources in order to enhance the capabilities for integrating all relevant parameters into the analysis of alternative systems and strategies in the electricity sector. Close co-operation has been established with other international organizations involved in related fields of activity.

In April, the Agency convened a meeting of international organizations for establishing an inter-agency project (DECADES) on databases and methodologies for the comparative assessment of different energy sources for electricity generation. The project is being carried out jointly by nine international organizations (the Agency, CEC, ESCAP, IIASA, OECD/NEA, OPEC, UNIDO, WMO and the World Bank) under the supervision of a Joint Steering Committee formed by representatives of all the participating organizations. The various organizations have signed a 'letter of understanding', by which they have agreed to contribute to the project according to their respective fields of expertise and in the context of their ongoing programmes. The 'Vienna Four', i.e. the four international organizations based in Vienna (the Agency, IIASA, OPEC and UNIDO), are jointly in charge of the secretariat. Several other international organizations and national institutes are associated with the project. The Joint Steering Committee held a meeting in November 1993 to discuss and review the status of the different elements of the project, i.e. the establishment of databases, the development of computer software and the compilation of information on models for comparative assessment. The undertaking of case studies to illustrate the application of the databases and tools in planning and decision support studies in different countries has been deferred to 1994, owing to budget reductions. The main results and outcomes from the project will be presented and discussed at a symposium on electricity, health and the environment, to be held in 1995.

Work has continued on the inter-agency (IAEA/UNEP/UNIDO/WHO) project on the assessment and management of the health and environmental risks of energy and other complex industrial systems. However, owing to reductions in the budget, the case studies to be carried out within this project have been deferred to 1994.

The work carried out under 'Subprogramme X', and especially that connected with the DECADES project, serves as the basis of the Agency's contribution to the activities of the Inter-Governmental Panel on Climate Change (IPCC) and of the United Nations Inter-Agency Committee on Sustainable Development (IACSD).

Assessment of costs of nuclear and other energy systems

A procedure for the calculation of nuclear fuel cycle and nuclear electricity generation costs was included in the Reference Technology Database (RTDB). Elements affecting advanced LWR plant generating costs were analysed.

Work has continued on collecting data and performing economic evaluations of potable water production through desalination using nuclear energy.

The economic aspects of the feasibility of flue gas desulphurization using the electron beam process were reviewed in support of a technical co-operation model project in Poland.

Consultants services focusing on the economics of emission abatement systems for power plants provided information and data for various technologies and their influence on overall electricity generation costs. These data will be introduced into the RTDB.

A Technical Reports Series publication on the assessment and comparison of waste management system costs for nuclear and other energy systems was completed. The report summarizes the existing waste management cost estimates for representative nuclear and fossil fuel cycles in order to provide a correct perspective of the economic and environmental aspects of the different means of production of electricity. The highest waste management costs were for a conventional coal plant, while the lowest costs were those associated with the gas fuelled combined cycle. The waste management costs for two reference nuclear fuel cycles (with and without spent nuclear fuel reprocessing) are almost identical (of the order of 3.8 mills/kW·h).

Comparative assessment of the health and environmental impact of nuclear power and other energy systems

The computerized database on the Health and Environmental Impacts of Energy Systems (HEIES) was completed and its structure was adapted to be consistent with an advanced commercial software package. A CRP was initiated to obtain up-to-date estimates on the health and environmental impacts of viable near-term options for producing electricity.

IAEA/UNEP/UNIDO/WHO project on risk assessment

Support was provided to case studies in Zagreb, Croatia, and North Bohemia, Czech Republic. A restructuring of the procedural guide on risk management was initiated on the basis of experience gained in case studies.

Comparative assessment of the ecological impact and effect on climate change of nuclear and other energy systems

The Agency participated in the plenary meeting of the Inter-Governmental Panel on Climate Change (IPCC), held in April, and in the meetings of two of its topical Working Groups, and is contributing to the preparation of the Second Assessment Report of the IPCC to be published in 1995. The Agency is the 'lead author', in co-operation with OECD/NEA, of the sections of the report related to the assessment of nuclear power in connection with measures to mitigate climate change.

Work has continued on the assessment of the potential role of nuclear power in strategies seeking to reduce greenhouse gas emissions. Preliminary results of the analysis of greenhouse gas emission factors for electricity generation chains, using a full-energy-chain approach, have shown that nuclear power and renewable energy sources are the most environmentally benign. The results from this study have been presented at major international meetings on energy, electricity and the environment.

A report on the net energy analysis of different electricity generation systems was prepared and will be published in early 1994 as an IAEA-TECDOC.

A Technical Committee meeting was held in Vienna to review and analyse the process by which a country selects an option (direct disposal or reprocessing) for the back end of the fuel cycle. The results will be published as an IAEA-TECDOC.

Incorporation of comparative assessments in energy and electricity planning

Work has continued on the integration of health and environmental aspects into the comparative assessment of different electricity generation options and strategies, in co-operation with other international organizations and within the framework of the inter-agency DECADES project. The project outline document has been finalized and the 'letter of understanding' has been signed by the participating organizations.

In the context of the joint project, the Agency has strengthened its co-operation with the World Bank, in particular through its representation in the Steering Committee for the Environment Manual project of the World Bank.

Work has continued on the establishment of the RTDB database, containing technical and economic parameters, and emissions and residuals, from different energy chains, i.e. fossil fuels, nuclear power and renewable sources, for electricity generation. Data have been collected and a computerized structure has been designed and implemented for storing and retrieving the data. A prototype version of the database has been implemented for testing purposes and an operational version will be completed in 1994. Country specific databases, using the structure of the RTDB, will be developed and work in this regard has already been initiated in co-operation with Member States.

International experts advised the Agency on the adequacy of the available international energy statistics for use in comparative assessments of greenhouse gas emissions from different energy sources. The experts recommended certain specific steps that should be undertaken to improve the databases; these recommendations have been noted with interest by, for example, the International Negotiating Committee for a Framework Convention on Climate Change (INC-FCCC).

A graphics user interface for personal computers was developed, using commercial software, in order to facilitate the display and handling of the information contained in the databases established in connection with the DECADES project. A demonstration prototype has been presented and discussed in technical meetings and released for evaluation purposes to a number of institutes in Member States and international organizations.

A Technical Committee meeting was held in Vienna on a database to assess the health and environmental impacts of nuclear fuel cycle facilities. The data on the emissions and other burdens (both radiological and non-radiological) and a draft working document on the assessment of the health and environmental impacts of nuclear fuel cycle facilities were discussed. There were discrepancies among the data submitted from various facilities and it was decided that further analyses and additional data were required before the document could be completed.

Publications

Series and No.	Title
IAEA-TECDOC-727	Manual for the classification and prioritization of risks due to major accidents in process and related industries

FOOD AND AGRICULTURE

Programme overview

The food and agriculture programme operated jointly with FAO is designed to assist Member States in using nuclear techniques in their agricultural research and development in order to improve the quantity and quality of food produced on a sustainable basis, reduce food losses, improve soil fertility and water availability and protect the environment. Certain aspects of these efforts are being facilitated through the increasing use of molecular biology techniques, which utilize radioactive isotopes as markers.

Significant advances were made in 1993 in work on restoring damaged soils and improving the efficiency of water use and phosphorus uptake by crops. It was possible to identify sorghum and millet cultivars which are productive when grown in salty soils. Moreover, in a four-year study, these salt-tolerant cultivars were found to ameliorate the undesirable properties of the soils. More economical use of water in irrigating sugarcane became possible with the discovery that irrigation can be greatly reduced or omitted during the period when the plant tillers and that yields could be improved by 30% by irrigating when the stems are elongating. Also, genotypes of wheat were identified that are superior in water use efficiency and in yields. Further provenances of the gum-arabic tree Acacia senegal *which are productive when grown in drought prone regions were identified. Extrabudgetary resources permitted the initiation of a new CRP on the agronomic evaluation of rock phosphate fertilizers.*

An interregional quality assurance service for ^{15}N analysis by optical emission spectrometry was initiated. Analytical services, mainly nitrogen isotope ratio determinations, were provided for CRPs and technical co-operation projects.

Progress was made in the genetic improvement of crops through the combined use of induced mutations and various other techniques such as in vitro propagation and cloning, doubled haploids, DNA based marker mutations, electrophoresis of proteins and flow cell cytometry for measuring ploidy. Useful mutations were induced in shoot tip cultures of the banana variety 'Grand Nain', which culminated in the release of a new variety, FATOM-1. This latter variety is showing superior characteristics in advanced trials in Australia, Colombia, Cuba, Egypt, Honduras, Malaysia and Pakistan. In order to make additional genetic improvements in banana, molecular methods were developed for the rapid screening of mutants with resistance to the devastating Black Sigatoka and Panama diseases. Additional improvements were achieved in wheat, rice, barley and common bean in the first phase of ARCAL VII, the Latin American regional project.

Progress was also made in improving plant architecture and oil quality and content by means of a CRP on genetic improvement of oil seed and industrial crops. Mutant varieties released include three rapeseed varieties in Bangladesh and China, and 19 sesame varieties in Egypt and the Republic of Korea. These results have generated the realistic expectation that the techniques can be employed to modify the quality of oil and protein according to the specific needs of human nutrition, animal feeding and industrial applications.

Increased emphasis will now be placed on basic food crops. In Africa this approach has already resulted in improved locally adapted varieties of cassava, yam, sweet potato, plantain, sorghum, African rice and some legumes. Improvements have been made in cooking quality, grain quality and drought tolerance. Gene transformation mediated through 'engineered' Agrobacterium *plasmids and ballistic vectors has been achieved in the case of banana.*

The transfer of advanced mutation and plant breeding technologies was facilitated by training activities. Many participants in the annual interregional training course held at the Agency's Laboratory at Seibersdorf become counterparts in technical co-operation projects and contract holders in CRPs. In addition, the Agency's Laboratory provided more than 600 radiation service treatments of seeds and other propagules for 48 Member States.

Throughout a wide spectrum of animal species and production systems, the use of isotopic methods to define nutritional and reproductive problems has demonstrated that the quality and quantity of nutrient supply is the principal determinant of productivity. Dramatic increases in growth rates, milk production and/or reproductive efficiency have been achieved by improving the nutrition of ruminant livestock by appropriate supplemental feeding with locally available agroindustrial by-products such as urea, molasses, palm kernel cake, rice polishings and leaves of leguminous trees.

The joint FAO/IAEA Central Laboratory for ELISA and Molecular Techniques in the Diagnosis of Animal Diseases was established in August at the Agency's Laboratory at Seibersdorf. It has been designated as a 'collaborating laboratory' by WHO and the International Office of Epizootics. The Central Laboratory will work to develop and apply internationally accepted standards for conducting disease diagnostic assays and for assuring the validity of the results.

Prospects for increasing the application of the sterile insect technique (SIT) to combat the Mediterranean fruit fly have been greatly enhanced by the development at the Agency's Laboratory, using nuclear techniques, of 'Vienna 42', a strain which allows the release of sterile males alone. This is important because sterile females persist in stinging the fruit, which allows the entry of microorganisms which cause the fruit to rot. Vienna 42 has a lethal gene tightly linked to the femaleness. This gene is not expressed at normal temperatures; however, if eggs are held at elevated temperatures the gene kills all eggs destined to become females. The genes involved in this genetic sexing mechanism have been transferred into the Mediterranean fruit fly strain found in Guatemala, and the latter will be utilized in the SIT campaign there beginning in 1994.

The SIT will be used against tsetse flies to eradicate this vector of African animal trypanosomiasis from Zanzibar, United Republic of Tanzania. A model project has been developed and it will be implemented as soon as sufficient donor funds have been collected.

Budget restrictions forced the termination of research activities at the Agency's Laboratory at Seibersdorf to develop the biological control pathogen Bacillus thuringiensis as a replacement for insecticides against the medfly.

In addition, the Agency's Laboratory developed an improved formulation of the photolabile pyrethrin derivative deltamethrin for use on target cloths which attract and kill tsetse flies. This formulation was evaluated through a CRP, as was a formulation of the herbicide thiobencarb for use on paddy rice. The thiobencarb formulation was tested successfully in Egypt, Hungary, Malaysia and the Philippines; it is to be included in a proposed UNIDO programme to establish manufacturing facilities in several Asian countries.

Following the successful eradication of the New World Screwworm from the Libyan Arab Jamahiriya, supporting work at the Agency's Laboratory was terminated at the end of 1993.

'Agenda 21' of the 1992 United Nations Conference on Environment and Development requires that the FAO Code of Conduct on the Distribution and Use of Pesticides be implemented by the year 2000. Considerable assistance has been given to Member States in gaining access to analytical facilities to control the quality of pesticide formulations (products) on the market, and to monitor pesticide residue levels in food and the environment. Moreover, quality assurance training is being included in CRPs, technical co-operation projects and interregional and regional training courses to support the enforcement of relevant legislation.

A document was produced containing guidelines for agricultural countermeasures following an accidental release of radionuclides, drawing on experience from the accident at the Chernobyl nuclear power plant. A CRP was initiated to obtain data on the transfer of radionuclides in tropical and subtropical food-chains.

Following a 1992 General Conference resolution, the Agency, jointly with FAO, has acted to facilitate the use of food irradiation on a commercial scale in developing countries. The first group of countries to be identified for assistance included Chile, China, Mexico and Morocco.

The major public health benefits that may be derived from food irradiation became clear from a symposium held in March. Food irradiation, especially of fruits and vegetables, was found to have economic advantages for disinfestation over the use of methyl bromide. At the final Research Co-ordination meeting on the Asian Regional Co-operative Project on Food Irradiation, 13 countries reported successful test marketing of irradiated foods. More than 130 000 t of food have been irradiated in these countries during the last three years.

The International Consultative Group on Food Irradiation (ICGFI) will continue until May 1999. It will work closely on food irradiation issues with the Agency, FAO, GATT (the General Agreement on Tariffs and Trade), the International Trade Centre (ITC)-UNCTAD/GATT and WHO, as well as with the food industry and the food trade.

SOIL FERTILITY, IRRIGATION AND CROP PRODUCTION

Maximizing biological nitrogen fixation and development of molecular biology techniques in microbial ecology

A CRP on the use of molecular biology in studies of microbial ecology has led to the development of a molecular biology technique called the GUS (beta-glucuronidase) gene marker technique to monitor soil microorganisms, such as *Rhizobium*, that help grain legumes and other leguminous species to fix atmospheric nitrogen. Addition of appropriate strains of *Rhizobium* to the soil results not only in enhanced nitrogen fixation but also in greater grain yields. However, the introduced strains are often excluded by the local strains present in the soil which are not quite as good in nitrogen fixation. The GUS gene marker will assist the study of rhizobial populations and their migration in the soil so as to develop protocols and practices for enhancing legume-*Rhizobium* symbioses and increasing soil fertility and grain legume production.

Measurement of nitrogen fixation in trees and management of agroforestry systems

In a CRP on optimization of N_2 fixation by tree crops for enhancing soil fertility and soil conservation, ^{15}N methodology is being applied to measure N_2 fixation in several multipurpose trees and to assess the effect of management practices such as pruning on N_2 fixation and release of N to associated crops. Data on genotypic differences in nodulation, growth and N_2 fixation have been found and the preliminary data on the effect of pruning is varied. Genotypic differences in dry matter and nitrogen accumulation have also been observed and these results indicate that the selection of nitrogen fixing trees based on both yield and N_2 fixation ability will greatly enhance their beneficial effects in agroforestry systems.

Optimizing the use of plant nutrients for sustainable agricultural practices and environmental protection

A CRP on increasing and stabilizing plant productivity in low phosphate soils in the semi-arid and subhumid tropics and subtropics has involved the search for genotypes of food crops and trees which are highly efficient in the use of limited supplies of water and phosphorus. Genotypes of wheat have been discovered which are efficient both in water use and the production of high yields. In the case of studies with trees, provenances of the gum-arabic tree *Acacia senegal* have been identified which are highly efficient in growing in drought prone regions. Detailed studies are now being conducted with the gum-arabic tree to identify the morphological features which make some provenances superior to others in their ability to live in arid environments.

Increasing the effective use of scarce water resources to maximize plant productivity

A CRP on the assessment of irrigation schedules of field crops to increase the effective use of water in irrigation projects is investigating growth stages of crops where a deficit of water supply will not significantly affect growth and yield. Preliminary data show that sugarcane is more sensitive to water deficit during stem elongation than during tillering. Substantial savings in water can be made by reducing or omitting irrigation at tillering. At the same time, guaranteed irrigation at stem elongation has led to improvements in sugar yields of 30%.

Increasing plant productivity in deleterious soils with emphasis on saline and highly acidic soils

A CRP on the use of nuclear techniques to improve crop production on salt-affected soils involved the identification of food crop and tree species capable of growing in salt-affected soils which are regarded as agriculturally unproductive. Of 20 cultivars each of sorghum and millet tested, one sorghum cultivar and one millet cultivar were identified as being highly tolerant to salinity. In a four-year study, these sorghum and millet cultivars also ameliorated the undesirable properties of soils, thus permitting the cultivation of cowpea, a salt-sensitive crop. The yields of cowpea in these soils have been increased by 86% and 37% on plots previously cropped with salt-tolerant cultivars of millet and sorghum. Similar observations have been made with lentil, rice, soybean, wheat, barley and tree species such as *Casuarina*, *Terminalia* and *Sesbania*.

Laboratory activities

Isotopic studies at the Agency's Laboratory at Seibersdorf in support of the programme on optimizing the use of plant nutrients for sustainable agricultural practices and environmental protection tested the agronomic effectiveness of phosphate rocks and formulations based on phosphate rock. Significant genotypic differences have been observed in phosphate uptake and use by various crop species. Preliminary studies on the quantification of greenhouse gases such as methane and nitrous oxide have also been conducted.

The Laboratory provided 33 person-months of training to 6 research fellows on the use of isotope and related nuclear techniques in soil/plant studies and isotope analysis. Analytical services, mainly nitrogen isotopic ratio determinations for approximately 10 000 plant and soil samples were provided for implementation of CRPs and technical co-operation projects. An interregional co-operation project providing an international quality assurance service for ^{15}N analysis by optical emission spectrometry was initiated. In addition, an advanced mass spectrometer facility was installed and commissioned for determinations of stable carbon isotope ratios of enriched materials as well as at natural abundance levels.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Increasing and stabilizing plant productivity in low phosphate and semi-arid and subhumid soils of the tropics and subtropics	1994	14
1990	Optimizing N_2 fixation in tree crops	1994	14
1990	The use of isotopes in studies to improve N_2 fixation of grain legumes with the aim of increasing food production and saving nitrogen fertilizers in the tropics and subtropics in Asia	1994	13
1990	Assessment of irrigation schedules of field crops to increase the effective use of water in irrigation projects	1995	17

CRPs established in the current year

Subject	No. of years	Participating institutions
The use of molecular biology in studies of microbial ecology	5	12
The use of nuclear and related techniques in the agronomic evaluation of phosphate fertilizers, in particular rock phosphate	5	18

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on the use of isotope and radiation techniques in studies on soil/plant relationships, with emphasis on soil water management	IAEA Seibersdorf	22	5 weeks
Regional course on the use of isotope and radiation techniques in studies of soil/plant relationships with emphasis on salt-affected soils	Turkey	18	4 weeks
Regional seminar for Asia and the Pacific on nuclear related methods in soil/plant aspects of sustainable agriculture	Sri Lanka	42	5 days

Publications

Series and No.	Title
External publication	Enhancement of biological nitrogen fixation of common bean in Latin America
External publication	Isotopic studies of *Azolla* and nitrogen fertilization of rice
Newsletter	Soils newsletter, Vol. 16, Nos 1 and 2

PLANT BREEDING AND GENETICS

Crop improvement in Latin America

The first phase of the Latin American regional project on the genetic improvement of seed propagated crops (ARCAL VII) has been completed. Activities were focused on mutation breeding and in vitro techniques such as the use of doubled haploids. Major crop improvements were achieved in wheat, rice, barley and common bean, resulting in the production of promising mutant lines and the release of mutant varieties.

Genetic improvement of basic food crops in Africa

In September, a Research Co-ordination meeting on the improvement of basic food crops in Africa through plant breeding, including the use of induced mutations, was held in Nairobi. The major objective of this project is the breeding of improved varieties of staple food crops for Africa with the emphasis on indigenous species. The use of mutation breeding proved to be very valuable, sometimes in combination with in vitro culture, in improving locally well adapted varieties of cassava, yam, sweet potato, plantain, sorghum, African rice and some legumes. Characters such as cooking quality, grain quality and drought tolerance have been ameliorated.

Genetic improvement of oil seed and industrial crops

A CRP on the mutation breeding of oil seed crops was completed. The major objectives were to improve yield by modification of plant morphology and other characteristics to suit specific agricultural systems and to improve oil quality by genetic modification of fatty acid composition. Three mutant rapeseed varieties were officially released in Bangladesh and China and 19 mutant varieties of sesame in Egypt and the Republic of Korea. Most of these were the product of ^{60}Co gamma irradiation; others were obtained through chemical mutagenesis or crosses with induced mutant varieties or lines. Significant progress has been made in the improvement of plant architecture and the modification of oil quality and content. Mutation breeding has proven to be an appropriate tool for oil seed crop improvement.

Molecular genetics for the improvement of seed propagated crops

A Research Co-ordination meeting on the application of DNA based marker mutations for the improvement of cereals and other sexually reproduced crop species was combined with another meeting on the use of novel DNA fingerprinting techniques for the detection and characterization of genetic variation in vegetatively propagated crops. It has become clear that DNA based marker mutations can be used to locate genetic factors for almost any character, whenever sufficient genetic variation and accurate evaluation methods are available. Genetic maps were initiated for some crops and extended for others.

Biotechnology for the improvement of vegetatively propagated crops

Sweet potato has been used as a model crop to study the improvement of root and tuber crops in tropical Asia using mutation breeding. Methods and protocols for combining mutation breeding with in vitro techniques were developed. Mutant clones with resistance to black rot, weevils and nematodes, and altered root shape were produced. These clones are under evaluation in China, Japan, the Philippines and Viet Nam.

Laboratory activities

The R&D work at the Agency's Laboratory at Seibersdorf focused mainly on the genetic improvement of vegetatively propagated and tropical crops (e.g. *Musa* ssp., *Manihot esculenta*) of major importance, through in vitro mutation breeding in association with advanced methods of molecular biology. In vitro mutation induction in explants of meristematic shoot tips and in nodal cuttings, which is followed by plant regeneration, was investigated. Chimeras derived from mutagen treatment of apical, multicellular primordials are dissolved through some subcycles of micropropagation, aiming at achievement of homohistont mutant plants. Somatic embryos and plants from cell suspensions were used to develop somatic cell manipulation procedures based on regeneration of plantlets from single cells. Methods for screening such plants for tolerance/resistance to diseases were studied in vivo and in vitro. Biochemical markers were applied for identification of genotypes of plant-fungus interactions tolerant to Panama disease in *Musa*. Bioassays for *Mycosphaerella* toxins were developed for screening induced genetic variation against the Sigatoka disease complex. Genetic markers were successfully used to detect genetic diversity between species and genotypes of *Musa*. Flow cytometry was applied for assessing ploidy, DNA content and other genomic features. Genetic engineering based on *Agrobacterium* and ballistic vectors for gene transfer yielded optimistic results in GUS positive BASTA transformants.

Mutant clones identified at the Agency's Laboratory were tested in several countries for agronomic performance such as yield, fruit quality and earlier harvest. Recently, a banana mutant clone with higher yield potential and outstanding fruit quality, 'FATOM-1', was derived from the most important cultivar of the banana variety 'Grand Nain' and made available to growers in FAO and Agency Member States. Additionally, a dwarf clone of banana with resistance to a new race of Fusarium wilt was agronomically improved by in vitro mutagenesis to a normal sized commercial cultivar, PARFIT.

Local cultivars of various species were brought to the Agency's Laboratory and used for experimental work. Protocols and techniques specifically developed for genetic improvement of a crop genotype were then directly applied in national programmes.

A radiation treatment service was provided at no cost to FAO and Agency Member States to foster the application of nuclear techniques in national crop improvement programmes. In 1993, more than 600 radiation service treatments for 48 Member States were provided by the Agency's Laboratory at Seibersdorf. Most of these were seed samples which were irradiated with ^{60}Co gamma rays.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Improvement of basic food crops in Africa through plant breeding including the use of induced mutations	1994	16
1992	Application of DNA based marker mutations for improvement of cereals and other sexually reproduced crop species	1997	15
1992	Use of novel DNA fingerprinting techniques for the detection and characterization of genetic variation in vegetatively propagated crops	1997	12

CRPs established in the current year

Subject	No. of years	Participating institutions
Induced mutations in connection with biotechnology for crop improvement in Latin America	5	12
Induced mutations for sesame improvement	5	10
Induced mutations and other advanced technology for production of crop mutants suitable for environmentally sustainable agriculture	5	14
In vitro techniques for selection of mutants better adapted to adverse environmental conditions	5	14

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on the induction and use of mutations in plant breeding	IAEA Seibersdorf	25	6 weeks
National course on mutation breeding	Mongolia	20	2 weeks
National course on mutation breeding	Ecuador	12	3 weeks

Publications

Series and No.	Title
IAEA-TECDOC-728	Use of induced mutations and in vitro culture techniques for improving crop plant resistance to diseases
Newsletter	Mutation breeding newsletter, No. 40
Newsletter	Mutation breeding review, No. 9

ANIMAL PRODUCTION AND HEALTH

Development of feeding and breeding strategies for improving the productivity of ruminant livestock in developing countries

Two regional CRPs and one interregional CRP were completed, covering a wide variety of livestock species (cattle, sheep, goats, old and new world camels and buffaloes) and agroecological zones in Africa, Asia and Latin America. These programmes focused on using isotopic methods to define nutritional and reproductive problems with respect to producing milk, meat and fibre, and to research ways of overcoming constraints in a cost effective manner. Throughout the spectrum of animal species and production systems examined, the quantity and quality of nutrient supply were shown to be the principal determinants of productivity, with other factors (e.g. reproductive management and animal genotype) being of secondary or of little importance. A range of options for improving feed supply were addressed — including the use of cereal straws and stovers and methods to improve the conversion of these into growth and milk production. These included treatment with alkali and provision of supplements based on locally available agroindustrial by-products, e.g. urea, molasses, palm kernel cake, rice polishings and legume tree leaves. These approaches led to considerable increases in growth rates, milk production and/or the reproductive efficiency of the animals concerned, and in a number of instances are now used by local smallholder farmers.

One of the major recommendations to arise from all programmes was the need in future activities to identify better the objectives of feed supplementation since individuals within animal populations have different requirements. Since the greatest nutritional and economic advantages in supplementary feeding are likely to come by promoting milk production in developing countries, future CRPs will target milk producing animals.

Seromonitoring of rinderpest in support of the Pan-African Rinderpest Campaign (PARC)

Work continued on providing technical guidance and standardized immunoassay kits developed by the Agency and the Pirbright Laboratories, United Kingdom, for detecting rinderpest antibodies in cattle blood. In support of this programme, guidelines were established by consultants for serological and disease surveillance of rinderpest to be used during both the phases of vaccination and the International Office of Epizootics (OIE) declarations of freedom from disease and virus.

Validation and use of immunoassay tests for the diagnosis of trypanosomiasis in African livestock

A CRP funded by the Government of the Netherlands was completed and a publication prepared. The programme promoted close collaboration between African institutes, the CGIAR's International Laboratory for Research on Animal Diseases (ILRAD) and the United Kingdom Centre of Tropical Veterinary Medicine with respect to the diagnosis, epidemiology and control of animal trypanosomiases in Africa. This collaboration resulted in the successful transfer to African institutes of highly sensitive and specific antigen enzyme linked immunosorbent assay (ELISA) diagnostic tests for cattle and camel trypanosomiases and has thereby enhanced substantially national and regional capabilities to diagnose these diseases.

Validation and international standardization of immunoassay test kits for the diagnosis and surveillance of selected viral, bacterial and parasitic diseases of livestock in developing countries

The Agency recently established, together with FAO, a Central Laboratory within the existing Animal Production Unit of the Agency's Laboratory at Seibersdorf. The aim is to develop and distribute immunoassay based disease diagnostic kits in support of programmes assisting veterinary services in developing countries to control and eradicate major diseases. This laboratory will also work in close co-operation with WHO and the International Office of Epizootics to develop and apply internationally accepted standards for conducting these assays and for assuring the validity of the results. By acting as the focal point for the development of international standards and the transfer of diagnostic methods based on biotechnology, the Central Laboratory will play a key role in assisting developing Member States to reduce the impact of animal diseases and the cost of their control. In 1993, the laboratory developed kits, protocols and computer based systems for expressing the results of diagnostic tests for foot-and-mouth disease, brucellosis and leukosis and these are now being used within the framework of national control and eradication programmes in Latin America, Asia and Africa.

Laboratory activities

The Agency's Laboratory at Seibersdorf provided technical support for projects in animal reproduction and nutrition through the production and distribution of standardized and validated kits for measurement of hormones and metabolites. Radioimmunoassay kits for the measurement of progesterone in milk and blood were distributed to approximately 70 counterpart laboratories and kits for the assessment of the protein, energy and mineral status of livestock were provided to 20 Member States. Enzyme linked immunosorbent assay kits equivalent to around one million assay units were provided in support of programmes to control or eradicate rinderpest from Africa and foot-and-mouth disease, brucellosis and babesiosis from Latin America. Tests for other diseases, for example leukosis, contagious bovine pleuropneumonia and trypanosomiasis, are currently undergoing extensive field evaluation.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Strengthening animal production research and disease diagnosis in Asia through the application of immunoassay techniques	1993	23
1989	Development of feed supplementation strategies for improving ruminant productivity on smallholder farms in Latin America through the use of immunoassay techniques (ARCAL III, Phase II)	1994	21
1990	Interregional network for improving the productivity of camelids	1993	20
1990	Serosurveillance of rinderpest in Africa	1995	23
1990	Immunoassay methods for the diagnosis and epidemiology of animal diseases in Latin America	1995	26
1992	Development of supplementation strategies for milk producing animals in tropical and subtropical environments through the use of nuclear and related techniques	1997	20

CRPs established in the current year

Subject	No. of years	Participating institutions
Use of immunoassay methods for improved diagnosis of trypanosomiasis and monitoring tsetse and trypanosomiasis control programmes	6	17
Development of feed supplementation strategies for improving the productivity of dairy cattle on smallholder farms in Africa	6	19

Publications

Series and No.	Title
IAEA-TECDOC-691	Feeding strategies for improving ruminant productivity in areas of fluctuating nutrient supply
IAEA-TECDOC-707	Improving the diagnosis and control of trypanosomiasis and other vector-borne diseases of African livestock using immunoassay methods
IAEA-TECDOC-708	Improving the productivity of indigenous African livestock
Newsletter	Animal production and health newsletter, Nos 15 and 16

INSECT AND PEST CONTROL

Improved economy and reliability of the sterile insect technique for use against tsetse fly vectors of animal trypanosomiasis

Owing to improved tsetse rearing and other activities, a greatly expanded sterile insect technique (SIT) project was initiated in Zanzibar, United Republic of Tanzania. The objective of the project is trypanosomiasis eradication by eradicating the tsetse fly. The cost of the project is about $6 million. The Agency estimates that this amount will be repaid in about three years by the reduction in losses caused by tsetse transmitted trypanosomiasis.

A CRP was initiated on the genetics of tsetse flies with the objective of improving the SIT against these vectors of trypanosomiasis.

As a result of the high cost of certain aspects of tsetse rearing, a CRP was initiated to automate certain aspects of the process. The automated procedures are targeted at the stages responsible for approximately 50% of the associated labour costs.

Development of radiation induced F_1 sterility for control of Lepidoptera pests affecting major food and fibre crops in developing countries

A CRP on F_1 sterility was initiated for the control of Lepidoptera (moth) pests of major food and fibre crops. F_1 sterility is particularly useful against moths as the technology takes advantage of the lower radiation dosage required compared with that necessary to obtain complete sterility. The result is that the insects released into the field are much more competitive. Progress is also being made on developing F_1 sterility for control of the diamondback moth, a major pest of vegetables throughout the world.

Isotope aided molecular biology and genetic engineering for the improvement of insect control technologies

With the successful development of the 'Vienna 42' genetic sexing strain of the Mediterranean fruit fly, work is being increased on developing an overall genetic sexing system for insects. This third phase of the project is based on the use of molecular biology and genetic engineering techniques and concentrates on fruit flies and tsetse flies. A CRP was initiated and collaborative work with other research institutes increased.

Laboratory activities

The Agency's Laboratory at Seibersdorf continues to provide support for the insect control programmes. Included is the major input into the development of the Vienna 42 genetic sexing strain of the Mediterranean fruit fly, the provision of more than one million tsetse flies to the SIT project in Zanzibar, and training of developing country scientists associated with Agency projects.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Laboratory and field evaluation of genetically altered medflies for use in sterile insect technique programmes	1993	10
1989	Development of practices for area-wide tsetse eradication or control with emphasis on the sterile insect technique	1994	12
1989	Genetic engineering technology for the improvement of the sterile insect technique	1994	7
1992	Evaluation of population suppression by irradiated Lepidoptera and their progeny	1997	19

CRPs established in the current year

Subject	No. of years	Participating institutions
Development of female medfly attractant systems for trapping and sterility assessment	5	11
Mating behaviour studies under field cage conditions	5	8

Training courses and seminars held

Course name	Location	No. of participants	Duration
FAO/IAEA regional course on the use of the sterile insect technique in combating tsetse flies	United Republic of Tanzania	21	4 weeks

Publications

Series and No.	Title
Proceedings Series	Management of insect pests: Nuclear and related molecular and genetic techniques
Panel Proceedings Series	Radiation induced F_1 sterility in Lepidoptera for area-wide control
Special publication	Programme for the eradication of the Mediterranean fruit fly from Algeria, Libyan Arab Jamahiriya, Morocco and Tunisia
Newsletter	Insect and pest control newsletter, No. 48

AGROCHEMICALS AND RESIDUES

Monitoring pesticide residues in food and the environment

A CRP completed in 1993 showed that in tropical soils DDT dissipates relatively quickly. Fifty per cent of an application disappears in a few months, as compared with the 4–10 years that are normal in temperate regions. While volatilization is the major mechanism, microbial, chemical and photochemical processes play a larger part than in temperate systems.

Work on the effects of organochlorine insecticides on flora and fauna in Africa has produced more results in 1993 than in the previous, drought affected year. Lindane, which is used as the test compound, is (like DDT) much less persistent in the tropics than in temperate climates. However, in almost all experimental plots it reduced the numbers of Collembola, ants and springtails for up to two months following application. It generally controlled corn stemborers effectively, although this was not always reflected in crop yield.

Development of controlled release and other formulations of pesticides using nuclear techniques

A CRP on controlled release formulations concluded with a seminar held in Vienna in September. There were two major outcomes of this CRP. One is a formulation of deltamethrin, for use on target screens deployed in tsetse fly control programmes, which retains its insecticidal properties in the field for much longer than the commercially available formulation. The new formulation has been supplied to an ongoing programme funded by the Netherlands and it is expected to be used in the forthcoming FAO/IAEA programme in Zanzibar, United Republic of Tanzania. The other product is a formulation of the herbicide thiobencarb for use in paddy rice. Trials in Egypt, Hungary, Malaysia and the Philippines showed it to be superior to commercial granule formulations. This is a candidate material for inclusion in a proposed UNIDO programme to establish manufacturing facilities for such formulations in a number of Asian countries.

Alleviating the adverse effects of excessive radionuclide contamination of the agricultural environment

A CRP was started with the objective of obtaining data on radionuclide transfer in tropical and subtropical food-chains. There are now 85 nuclear power reactors in the tropics and subtropics, and relevant information is thus required to set release limits for radioactive effluents. In addition, transfer parameters are needed to devise agricultural countermeasures in the event of an accidental release of radionuclides.

Laboratory activities

The Agency's Laboratory at Seibersdorf gave substantial support to CRPs, particularly those concerned with the effects of organochlorine pesticides on flora and fauna in Africa, the development of controlled release formulations of pesticides and the use of nuclear and immunochemical methods of analysis. Analytical quality assurance services were provided for appropriate CRPs and technical co-operation projects.

Considerable work was devoted to improving the deltamethrin formulation for use on tsetse fly target screens. Not only is the preparation now available more persistent than the commercial product, but it can also be applied simply by dipping the cloth into the solution. With most formulations this is not feasible because the insecticide is held preferentially by the cloth, so that in a series, the amount retained declines progressively. This formulation should, therefore, reduce waste and also operator exposure compared with material that can only be applied as a spray.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Development of controlled release formulations of pesticides utilizing nuclear techniques	1993	13
1989	Radiotracer studies of the behaviour of DDT in tropical environments	1993	13
1989	Radiotracer studies to reduce or eliminate pesticide residues during food processing	1994	11
1990	Adverse effects on flora and fauna from the use of organochlorine pesticides on the African continent	1995	22
1992	Development of procedures to stabilize acaricides in livestock dips and of simplified methods to measure their concentration using nuclear techniques	1996	10
1992	Use of isotopic tracers in studies of herbicide performance in grasses and sedges	1997	9

CRPs established in the current year

Subject	No. of years	Participating institutions
The use of nuclear and immunochemical methods for pesticide analysis	5	14
Radionuclide transfer from air, soil and fresh water to the food chain of man in tropical and subtropical environments	5	14

Publications

Series and No.	Title
IAEA-TECDOC-695	Use of isotopes in studies of pesticides in rice-fish ecosystems

FOOD PRESERVATION

Acceptance of irradiated food in international trade

An independent review panel recommended the extension of the mandate of the International Consultative Group on Food Irradiation (ICGFI) for another five years, i.e. until May 1999, following a review of progress and achievements. At the tenth annual meeting of the ICGFI in November, 22 member countries agreed to the extension of the mandate. Future work will place emphasis on the requirements of an increasing trade in irradiated food. Close collaboration with interested international organizations and those representing consumers, the food industry and trade will be sought.

Control of the food irradiation process

Two Food Irradiation Process Control Schools (FIPCOS), one each for operators/technical supervisors of irradiation facilities and food control officials, were organized by ICGFI. FIPCOS is increasingly recognized by national authorities; the training is contributing to the acceptance of food irradiation by national authorities and is helping to facilitate international trade.

An international inventory of authorized food irradiation facilities was issued by the ICGFI Secretariat. This includes some 20 out of over 50 commercial/demonstration irradiators being used for processing food for commercial purposes and under the control of national authorities.

Demonstration of technoeconomic feasibility of food irradiation in developing countries

Two regional CRPs were completed. A UNDP funded CRP related to the Asian Regional Co-operative Project on Food Irradiation — with emphasis on process control and acceptance — was concluded at the final Research Co-ordination meeting, held in the Republic of Korea in September. The participants reported successful test marketing of several irradiated food items. Irradiation has been used for processing food for commercial purposes in China, Indonesia, Japan, the Republic of Korea and Thailand. Some 130 000 t of food have been irradiated for different purposes in these countries in the past three years. During this project, large demonstration irradiation facilities were built in Bangladesh, China and Viet Nam and one commercial irradiator was built in Indonesia.

The cost-benefit aspects of food irradiation as a method for reducing food losses and food-borne diseases and facilitating food trade was evaluated at a symposium held in Aix-en-Provence, France, in March. From the papers presented at the symposium it was clear that irradiation offers considerable potential public health benefits in controlling a number of food-borne diseases. The economic impact of irradiation as a substitute for methyl bromide, the most widely used fumigant for food and agricultural products, in trade in a number of food products, especially fruits and vegetables, was reported. A highlight of the symposium was the report of the successful sale of several irradiated food items at retail level in the USA.

Use of irradiation in combination with other food processes

It was concluded, as a result of consultants services focusing on irradiation for shelf-stable food, that the production of this type of food using irradiation in combination with other processes would result in increased variety and improved quality and would facilitate wide food distribution in both advanced and developing countries. A report will be published in 1994.

Demonstration of the effectiveness of irradiation in reducing the incidence of food-borne parasites and pathogens

Following a positive recommendation of the joint consultation held with PAHO in Washington, D.C., in October 1992, a CRP on the use of irradiation as a public health intervention measure to control cysticercosis/taeniasis and *Vibrio* infection in Latin America and the Caribbean has been implemented under the joint sponsorship of the two organizations.

General activities

A detailed project proposal for introducing commercial scale food irradiation in developing countries was prepared, in consultation with FAO and WHO, and submitted to the Board of Governors at the June 1993 session. The proposal described the purpose of and prerequisites for governments to participate in the project, the types and extent of assistance and information to be provided by the Agency and estimates of the costs of such assistance, including the costs of an irradiation facility and associated infrastructure. The Board unanimously approved the project proposal, which was endorsed at the regular session of the General Conference.

Databases on authorized food irradiation facilities and on irradiated product clearance by national authorities were maintained and updated. Steps were taken to collaborate with the United States Department of Agriculture in establishing the Food Irradiation Information Centre at the National Agricultural Library in Beltsville, Maryland, USA, under the FAO/IAEA/WHO Collaborating Centre for Food Irradiation Information.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Food irradiation programme of Middle East and European countries	1993	12
1989	Application of irradiation techniques for food processing in Africa	1993	11
1990	Analytical detection methods for irradiation treatment of foods	1994	21
1990	Food irradiation process control and acceptance in Asia	1993	16
1990	Irradiation in combination with other processes for improving food quality	1995	19
1992	Irradiation as a quarantine treatment of mites, nematodes and insects other than fruit fly	1997	15

CRPs established in the current year

Subject	No. of years	Participating institutions
Irradiation as a public health intervention measure to control food-borne diseases (cysticercosis/taeniasis and *Vibrio* infection) in Latin America and the Caribbean (under the co-sponsorship of PAHO)	5	15
Standardized methods to verify the absorbed dose of irradiated fresh and dried fruit, and tree nuts in trade	5	15

Training courses and seminars held

Course name	Location	No. of participants	Duration
ICGFI Food Irradiation Process Control School for Food Inspectors	Hungary	14	2 weeks
ICGFI Food Irradiation Process Control School for Operators	Canada	14	3 weeks
FAO/IAEA African regional course on food irradiation	Algeria	11	2 weeks
FAO/IAEA group fellowship training on the technoeconomics of food irradiation	USA	15	4 weeks
ICGFI/IOCU seminar on food irradiation and consumers	Netherlands	35	3 days
FAO/IAEA group course for Latin America and the Caribbean to satisfy quarantine regulations	USA	17	4 weeks
ICGFI public information seminar on food irradiation for Latin America	Mexico	18	3 days

Publications

Series and No.	Title
Proceedings Series	Cost–benefit aspects of food irradiation processing
IAEA-TECDOC-688	Irradiation of poultry meat and its products: A compilation of technical data for its authorization and control
IAEA-TECDOC-696	Harmonization of regulations on food irradiation in Asia and the Pacific

HUMAN HEALTH

Programme overview

The implementation strategy adopted during the year in the human health programme followed the new initiatives set in motion during 1992. It placed greater emphasis on creating mechanisms to reach most users of nuclear medicine and radiotherapy instruments in developing countries, aiming to promote schemes for quality assurance in whole clinical processes in order to increase effectiveness in both specialties.

In the field of nuclear medicine the main areas of focus included:

- *Cost reduction of capital investment by building up indigenous capabilities in Member States in the production of radioactive reagents and radiopharmaceuticals used in the diagnosis of diseases, and by making available gamma cameras and data processing systems at lower cost.*
- *Introduction of useful and recent in vitro techniques for the diagnosis and large scale screening of high risk population for diseases such as hypothyroidism, hepatitis and other blood borne diseases.*
- *A new initiative in the therapeutic field addressing two important diseases — metastatic cancer of bones and hyperthyroidism — where other modalities of treatment have been shown to be less effective.*
- *Involvement of other bodies interested in nuclear medicine in developing countries such as national and regional societies of nuclear medicine, regional and international organizations (PAHO/WHO), manufacturers and suppliers, to form an association with actual users of nuclear medicine instruments to promote quality in nuclear medical practice. The Agency collaborated with the Latin American Association of Societies of Nuclear Medicine and Biology (ALASBIMN) in the formal foundation of the Ibero-American Board for the Certification of Nuclear Physicians in Latin America, Spain and Portugal. The Statutes and Foundation Act were formally signed by the first Executive Committee in October 1993, in Bogotá, Colombia. The first examination for the certification of specialists will be supported by the Agency and will be held in the last quarter of 1994.*

The principal emphasis in the field of applied radiation biology and radiotherapy was on upgrading and strengthening indigenous skills and capabilities in developing countries for therapeutic management of malignant tumours. The main topics dealt with were computer assisted radiotherapy planning for cancer of the cervix and head and neck tumours, the introduction of new techniques for brachytherapy of cancer, and the building up of a database of radiobiological criteria for determining the radioresponsiveness of human tumours to radiation. The task of enhancement of radiation induced therapeutic gain in cancer therapy by the application of radiosensitizers and/or cytostatics in combination with radiation was identified as an important clinical/scientific area of concern for all Member States and action has been taken towards the implementation of co-operative randomized controlled clinical trials under the auspices of the Agency. Attention has also been focused on strategies to improve radiotherapy in Latin America by the implementation of a joint IAEA/PAHO/WHO regional programme for the quality assurance of cancer radiotherapy in the region.

Another activity focused on the development of criteria for assessing the health impact of toxic chemical pollutants released from conventional energy sources that would allow quantitative comparison with the effects of low level radiation from nuclear technology.

The support of the IAEA/WHO Network of Secondary Standard Dosimetry Laboratories (SSDLs) was intensified. The calibration service of secondary standard dosimeters provided by the Agency for SSDLs is increasingly utilized by developing countries. The quality of the work by the SSDLs *is now checked by the Agency through an annual Thermoluminescent Dosimetry (TLD) Service and in special cases with ionization chamber intercomparisons. The proper use of dosimeters at radiotherapy centres is checked through the IAEA/WHO postal dosimetry service. This activity has now reached about one thousand radiation therapy units, mainly in developing countries. Both TLD services have been extended to check the dosimetry for photon beams of medical accelerators, in addition to* ^{60}*Co radiation therapy units. A quality assurance programme was set up for radiotherapy dosimetry to improve the success of radiation treatments. The Agency fully took over the technical activities of the International Dose Assurance Service (IDAS) for radiation processing dosimetry. The calibration and evaluation of dosimeters used for IDAS are performed by the Agency's Laboratory at Seibersdorf. Also, calibration traceability to the international measurement system is now supplied by the Agency.*

The human nutrition programme provides assistance in the development and application of nuclear techniques to solve problems in developing countries. The 1993 programme had two major subprogrammes, one on strategies for the prevention of micronutrient malnutrition in women and children, and the other on interactions between infection, diet and growth in children in developing countries. Both subprogrammes have been identified as high priority topics by United Nations organizations concerned with nutrition (principally FAO, UNU and WHO).

Health related environmental studies have continued to place emphasis on the use of nuclear analytical techniques for studying non-radioactive pollutants in environmental samples and human tissues. A recent change in the emphasis of this programme has been effected to help meet some of the goals of 'Agenda 21' of the 1992 United Nations Conference on Environment and Development, as well as newly emerging quality management and quality assurance standards (e.g. ISO-25).

In accordance with 'Agenda 21', improved inter-agency co-operation on marine pollution monitoring was promoted by the signing of a trilateral Memorandum of Understanding between the Agency, UNEP and the IOC of UNESCO and of an 'umbrella' contract between the Agency and UNEP. Coupled with the effects of increased external support from other international sources, these new arrangements have resulted in a trebling of extrabudgetary funding for IAEA-MEL during the past three years. Of particular importance in 1993 were the continuation by IAEA-MEL of pollution assessment in the post-war Persian Gulf environment and the commencement of a new CRP funded by the Swedish International Development Authority on the use of radiotracer techniques to study the behaviour of pesticide residues in the tropical marine environment.

NUCLEAR MEDICINE

General

The strengthening and upgrading of nuclear medicine projects has been achieved largely through technical co-operation projects and regional co-operation programmes. Four gamma cameras and computer systems were installed, out of which three were in the African region. Tomographic imaging systems were procured for two Member States to upgrade their capabilities for organ imaging in nuclear medicine.

A hardware interface and processing software for nuclear medicine imaging were developed through technical contracts. Efforts are being made to induce manufacturers of gamma cameras to produce low cost systems. Capabilities for indigenous production of reagents and radiopharmaceuticals are being enhanced through technical co-operation programmes and co-ordinated research projects. All these activities are essentially aimed at cost reduction in nuclear medicine practice in developing Member States.

Preventive maintenance and fault repair of nuclear medical instruments have been integrated with quality control checks, particularly on the gamma camera, which is the major instrument in nuclear medicine today. Two CRPs, one in Asia and one in Latin America, were initiated in this area.

Development of indigenous capability to conduct screening programmes for hepatitis B in developing countries

Significant steps were taken towards establishing local supplies of reagents for screening of hepatitis B infection in Asia. The screening programme was based on bulk reagent radioimmunoassay methodology to achieve cost reduction while maintaining the reliability of assay results. A new external quality assurance scheme (EQAS) for data processing was developed in collaboration with WHO and an instruction manual has been published to supplement IAEA-TECDOC-509, a user's manual on a radioimmunoassay data processing program for personal computers.

Therapeutic applications of unsealed radioactive sources

Co-ordinated research programmes, incorporating closely monitored and controlled randomized clinical trials, were initiated with regard to two important diseases, metastatic bone cancer and hyperthyroidism.

Enhancing the capabilities of developing countries to perform dynamic functional studies

At an interregional seminar held in Vienna, information was presented on recent advances in the application of radionuclide techniques in the diagnosis and management of disorders of the kidney, and the urinary and gastrointestinal tract. On the basis of this information, a document is being prepared for publication.

Screening for neonatal hypothyroidism

Significant progress was made in the building up of local capabilities for reagent supplies for the screening of neonatal hypothyroidism in the Asian and Latin American regions. As in the case of the screening programme for hepatitis B, this programme was based on bulk reagent radioimmunoassay methodology.

Diagnosis of communicable diseases

Progress was made in optimizing radionuclide based molecular techniques for the diagnosis of tuberculosis and blood borne diseases such as hepatitis, Chagas disease, AIDS and malaria. Results from two CRPs on the subject will provide data on the usefulness of these techniques in clinical diagnosis and screening programmes.

Nuclear techniques in the early diagnosis of cancer

The results of a CRP to introduce the use of labelled monoclonal antibodies ($^{99}Tc^{m}$-anti-CEA Ab) for the diagnosis of colorectal cancer are encouraging in that the accuracy of the method for early detection of local recurrences and distant metastasis was found to be at least as good as, and in many cases superior to, that obtained by alternative methods. The results will be presented at the World Congress of Nuclear Medicine in Sydney, Australia, in 1994.

A new CRP was initiated with the aim of determining therapeutic strategies in patients with cancer of the breast by studying the biological sensitivity of tumours in order to identify those that would be amenable to hormonal therapy.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1987	Radioaerosol inhalation imaging in the diagnosis of respiratory diseases in developing countries (RCA)	1993	10
1988	Basic and preventive maintenance of nuclear medicine instruments (RCA)	1993	11
1988	Development of diagnostic reagents for communicable diseases using radiation processing techniques	1994	6
1989	Evaluation of imaging procedures for the diagnosis of liver diseases: Phase II	1993	13
1989	Quality control and preventive maintenance of nuclear and related equipment in Africa	1994	9
1989	Quality control and preventive maintenance of nuclear medicine equipment in Latin America	1993	12
1989	Quality control of advanced nuclear equipment in Asia	1993	9
1990	Nuclear techniques for the early detection of hypothyroidism (ARCAL VIII)	1995	15
1991	Detection of colonic cancer by immunoscintigraphy using $^{99}Tc^{m}$-anti-carcinoembryonic antigen monoclonal antibodies	1994	10
1991	Diagnosis of blood borne diseases using ^{32}P labelled nucleic acid probes (Latin America)	1994	7
1991	Diagnosis of tuberculosis using nucleic acid probes	1994	12
1991	Measurement of alphafetoprotein by radioimmunoassay in the discrimination of liver-space-occupying lesions	1994	10
1992	Nuclear investigations of cerebral function	1994	8
1992	Qualitative nuclear cardiology	1995	8

CRPs established in the current year

Subject	No. of years	Participating institutions
Comparative evaluation of efficacy and toxicity of I.V. ^{89}Sr and oral ^{32}P in the palliative treatment of painful skeletal metastasis (deferred programme)	3	4
Development of indigenous capability to conduct screening programmes for hepatitis B in developing countries (RCA)	3	8
Nuclear techniques for diagnosis of bacterial and viral infections (Africa) (deferred programme)	3	3

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on nuclear medicine	Germany	27	4 weeks
National course on radioimmunoassay	Sudan	17	2 weeks
National course on radioimmunoassay, quality control, data processing and external quality assessment	Thailand	15	2 weeks
Regional course in interventional studies in nuclear medicine	Colombia	20	2 weeks
Regional course in medical scintigraphy	Cuba	20	4 weeks
Regional course in nuclear medicine for junior physicians (Africa)	Egypt	15	3 weeks
Regional course in troubleshooting and repair of gamma cameras	India	16	4 weeks
Regional course on the preparation of basic reagents for the radioimmunoassay of hepatitis B markers	China	18	2 weeks
Regional course on the preparation of basic reagents for the radioimmunoassay of thyroid related hormones	Morocco	18	2 weeks
Regional course on the optimization of reagent production techniques and the organization of regional reagent distribution schemes	Mexico	23	2 weeks

APPLIED RADIATION BIOLOGY AND RADIOTHERAPY

Radiation sterilization of medical supplies

The second phase of the tissue bank programme was extended to include 12 developing RCA Member States, permitting local production of tissue grafts, such as bones, chorion amnion, skin and fascialata in accordance with the regional criteria for clinical safety and quality. Surgical applications of radiation sterilized tissue grafts continued, with follow-up investigations to evaluate their remedial success rate.

Computer assisted radiotherapy planning for cancer of the cervix

The use of inexpensive computerized treatment planning systems has been introduced in several radiotherapy departments which hitherto had relied on manual planning and dosimetry techniques. Adequate software programs for teletherapy, brachytherapy, combined teletherapy and brachytherapy, tumour registration and basic statistics, and options for various radiobiological models have been developed. The results from the programme are being compiled for publication as an IAEA-TECDOC.

Advanced techniques in brachytherapy

The development of after-loading techniques which effectively eliminate the exposure of staff to radiation has resulted in a general resurgence of interest and an increasing role for brachytherapy in cancer management. Various clinical applications now include interstitial, intracavitary, intraluminal and surface moulds. The availability of a wider range of radionuclides in miniaturized forms, of varying properties and energies, coupled with generally improved technologies for imaging procedures and after-loading, now permit better dose distribution within the target volume. This is further aided by the availability of inexpensive personal computer based treatment planning systems. A new CRP in this area is aimed at exploring the potential for introducing high dose rate brachytherapy techniques and transferring the skill and technology to developing countries.

Comparative assessment of mutagenic and carcinogenic effects of low level radiation and toxic chemicals released from energy cycles

Research is continuing in a CRP on an assessment of the mechanisms involved in mutagenic and carcinogenic effects from exposures to low level radiation and genotoxic chemical pollutants, respectively. The work programme was assisted by the introduction and validation of current molecular radiobiology techniques in the subject field, which were reviewed by experts at an interregional seminar in Nairobi, Kenya.

Exploration of the stimulative effects of low dose radiation

Results confirming the existence of an adaptive response to low dose radiation were obtained through a CRP. Some of the molecular mechanisms involved are also being studied. The findings may have an impact on the interpretation of low dose radiobiological effects and, in particular, may be important in related risk assessment studies.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1990	Computer assisted planning and dosimetry in radiotherapy of carcinoma of the cervix in the Asia and Pacific region (RCA)	1994	10
1990	Computer assisted planning and dosimetry in radiotherapy of head and neck cancers	1993	9
1990	Exploration of the molecular mechanisms of the stimulatory effect (i.e. adaptive response) of low dose and low dose rate radiation	1993	13
1990	Microbiological quality control and sterility safety evaluation in radiation sterilization of local medical supplies in Latin America	1994	6
1990	Radiobiological impact of hot beta particles from the Chernobyl fallout: risk assessment	1993	16
1992	Comparative assessment of mutagenic and carcinogenic effects of low level radiation and toxic chemicals released from energy cycles	1995	6
1992	Radiation responsiveness criteria for human tumours determinant for therapeutic modality planning	1995	13

CRPs established in the current year

Subject	No. of years	Participating institutions
Modern techniques in brachytherapy of cancer with special reference to the developing countries	3	5

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on applications of radioisotopes and molecular techniques in biological sciences significant for human health problems	Japan	17	4 weeks
Regional workshop on radiation sterilization of tissues	Viet Nam	16	2 weeks
Regional workshop on total quality systems for tissue banking of radiation sterilized surgical grafts	Indonesia	25	2 weeks
Interregional seminar on radiobiological techniques in the comparative estimation of carcinogenic induction by chemical pollutants and low dose radiation	Kenya	52	1 week

DOSIMETRY

Secondary Standard Dosimetry Laboratory (SSDL) network

The IAEA/WHO Network of Secondary Standard Dosimetry Laboratories (SSDLs) presently includes 67 laboratories and 6 national organizations in 54 Member States, as well as 14 affiliated members (i.e. primary standard laboratories). The support of the member laboratories has been continued to raise the level of performance to internationally acceptable standards. Services continued in the areas of calibration and dose intercomparison, as well as support for technology transfer. Calibrations of 26 ionization chambers of secondary standard dosimeters and hospital reference dosimeters with a total of 142 radiation qualities, nearly 2000 reference irradiations for Member States and on-site training for SSDL staff were provided by the Agency's Laboratory at Seibersdorf. The quality of the work by SSDLs was checked by the annual comparison with thermoluminescent dosimeters. Recommendations for a code of practice on radiation measurements with plane parallel ionization chambers were prepared and discussed at a consultants meeting.

Dose intercomparison and assurance

The operation of the IAEA/WHO Thermoluminescent Dosimetry (TLD) Service was continued for radiotherapy centres of Members States. About four hundred sets of dosimeters were distributed for the monitoring of dosimetry in ^{60}Co beams or for monitoring photon beams of medical accelerators at radiation therapy centres and SSDLs. A trial dose intercomparison was performed for 17 electron beam qualities of medical accelerators.

The International Dose Assurance Service (IDAS) for radiation processing facilities was continued. A total of 48 alanine dosimeter sets were distributed to 15 participating institutes from 12 Member States. The Agency's reference standard dosimetry system for high dose measurements, namely alanine/ESR dosimetry, was calibrated by the National Physical Laboratory (the primary standard laboratory in the United Kingdom) establishing calibration traceability to the international measurement system. The second Research Co-ordination meeting for the CRP on quality control dosimetry for particle beam radiation processing was held. It was agreed that the dosimetry system presently used by the Agency for gamma rays, i.e. alanine/ESR, is equally suited to an anticipated IDAS programme for electron beams. A syllabus for a training course for facility operators on the subject of process control and quality assurance for radiation processing was prepared.

Transfer of dosimetry techniques

A symposium on measurement assurance in dosimetry was held. All the different steps in the transfer of calibrations for dosimeters from the primary via secondary standard laboratories to the users were discussed.

The first draft of a manual on dose determination in a target volume in radiation therapy was prepared and discussed by consultants. This manual will help radiotherapy departments to determine the dose at a point of interest in the patient from the calibrations performed in a standard geometry in a water phantom.

Transfer of dosimetry techniques *(cont.)*

Recommendations for a technical document on absorbed dose intercomparison methods used by the Agency were prepared. Such intercomparisons are performed to reveal errors and improve the accuracy in dosimetry by SSDLs, radiotherapy centres and high dose irradiation facilities. TLD, ionization chambers, and alanine/ESR dosimetry are used for the measurements.

A quality assurance programme for radiation therapy has been started in co-operation with the European Society for Therapeutic Radiology and Oncology (ESTRO) in order to improve radiation dosimetry at radiation therapy centres.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Testing of the code of practice on absorbed dose determination in photon and electron beams	1993	9
1988	Development of quality control dosimetry techniques for particle beam radiation processing	1995	9
1989	Performance testing of dosimetry equipment	1993	8
1991	Therapy level dosimetry with alanine/ESR system	1993	5

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on radiotherapy dosimetry	Algeria	37	3 weeks
Regional course on radiotherapy treatment planning	Thailand	31	3 weeks
Regional course on radiotherapy treatment planning	Turkey	49	3 weeks
Regional course on standardization of dose measurements through SSDLs	Australia	20	3 weeks
Regional workshop on process control and quality assurance for radiation processing	Czech Republic	12	1 week

Publications

Series and No.	Title
Newsletter	SSDL newsletter, No. 32

NUTRITIONAL AND HEALTH RELATED ENVIRONMENTAL STUDIES

Applied human nutrition research using nuclear and isotopic techniques

Work conducted during 1993 focused on a number of projects relating to protein energy malnutrition and micronutrient malnutrition. A CRP was initiated on the application of stable isotope tracer methods to studies of amino acid, protein and energy metabolism in malnourished populations of developing countries. It is concerned particularly with assessing possible changes in protein requirements associated with infection in malnourished children. Its goal is to give a stronger scientific basis for tailoring dietary intake which will meet nutrient requirements during recovery. A new approach was adopted in implementing this programme. Selected participants in developing countries are specifically twinned with an advanced laboratory in a developed country, which provides the necessary technical expertise and backup. This CRP, which presently comprises 16 participants in 10 countries, is partly supported by additional funding provided by the Government of the USA. Detailed protocols for the CRP were discussed and agreed at the first Research Co-ordination meeting, which was held in Boston, USA.

Work continued under a CRP on micronutrient malnutrition in 11 countries. This programme is mainly concerned with iron deficiency anaemia (the world's most prevalent nutritional deficiency, which affects more than 2000 million people in more than 100 developing countries). Significant progress was achieved in developing in vitro techniques for assessing iron bioavailability. These techniques are expected to simplify research aimed at improving iron nutrition through better selection and preparation of locally available foodstuffs.

Preparation continued of a publication in the IAEA-TECDOC series that will provide Member States with advice on applications of isotope techniques in human nutrition research. It will also cover aspects relating to radiation protection, licensing procedures and ethical requirements.

Applied research on environmental pollution using nuclear and isotopic techniques

The first Research Co-ordination meeting was held in Vienna for a CRP on applied research on air pollution using nuclear related analytical techniques. Agreement was reached on the detailed protocols to be followed for the collection and analysis of airborne particulate matter in urban and remote areas of each of the participating countries, and on procedures to be followed for the analysis and quality control of such measurements. This CRP is expected to provide data on the composition of atmospheric aerosols in 19 different countries using validated techniques of collection and analysis.

Two new human hair reference materials containing, respectively, low and high levels of methyl mercury were developed for use by participants in a CRP on the assessment of environmental exposure to mercury in selected human populations as studied by nuclear and other techniques. After additional tests of homogeneity, these materials are due to be certified in an international intercomparison exercise, which will be organized early in 1994.

An intercomparison on trace and minor elements in candidate lichen research material (IAEA-336) was completed. It is based on 41 independent sets of results submitted by participants in 26 Member States. The final evaluation of the data is in progress. It is expected that this material, which will have certified concentrations for more than twenty elements, will be a significant aid in studies of environmental pollution using biomonitors (such as lichens and mosses).

Applied research on environmental pollution using nuclear and isotopic techniques *(cont.)*

A regional seminar on environmental applications of radiation and isotopes was held in Santiago, Chile. A large part of the programme of the seminar was concerned with applications of nuclear analytical techniques (NATs) in environmental studies. A round table on this subject concluded that NATs are highly suitable for multi-element instrumental analysis of a wide range of environmental samples. Particularly appropriate matrices include airborne particulate matter, soils, sediments and a variety of bio-environmental materials, including biomonitors of environmental pollution such as mussels, lichens and human tissues such as hair. In most such applications, NATs are still the method of choice despite recent advances in other non-nuclear methods such as atomic absorption spectroscopy, inductively coupled plasma emission spectrometry and inductively coupled plasma mass spectrometry.

Many of the same themes have also been taken up in a subproject on nuclear analytical techniques. This is part of a recently established Joint UNDP/RCA/IAEA project on the use of isotopes and radiation to strengthen technology and support environmentally sustainable development. The Agency is supporting this project in 12 RCA Member States by organizing workshops and by providing quality assurance and other related services.

A new project was launched, in collaboration with UNEP, to update the Agency's database on certified analytical materials for environmental studies; the previous revision dates from 1990. A technical report is due to be issued in 1994. Other technical reports in preparation are on sampling and data evaluation methodologies for airborne particulate matter (with special reference to the use of nuclear and related methods of analysis), and on the radioanalysis of water.

Services to international pollution monitoring programmes

'Agenda 21' of the 1992 United Nations Conference on Environment and Development identified the need to strengthen inter-agency co-operation. To this end, the Agency signed a new Memorandum of Understanding with the IOC of UNESCO and UNEP to ensure co-ordination of joint programmes centred at IAEA-MEL. Last year saw the introduction of a new 'umbrella' project between UNEP and IAEA-MEL, the significance of which is an increase in extrabudgetary support and in contract security and enhanced levels of efficiency of resource usage. Within this framework, IAEA-MEL provides comprehensive technical support to assess marine pollution. In 1993, staff conducted advisory and technical missions to 27 countries. Extended specialist training activities were provided in Albania, Cyprus, Egypt, Mexico, Nicaragua, Slovenia and Tunisia. The instrument maintenance engineer installed new equipment (donated through UNEP and the World Bank) in Slovenia and Albania and conducted seven service visits to monitoring laboratories.

Quality assurance work within the Analytical Quality Control Service (AQCS) programme continued and six materials were distributed for intercomparison purposes. Substantial efforts were also directed to producing a critical review of data quality for the 19 years during which the Co-ordinated Mediterranean Pollution Monitoring and Research Programme (MEDPOL) has been under way.

Co-operation with the IOC of UNESCO continued. A joint intercomparison exercise for organic pollutants in the southwest Atlantic region was completed in 1993 and results were jointly interpreted. In addition, IAEA-MEL was active in the International Mussel Watch project set up through the IOC to assess global distribution and investigate the transport of persistent organochlorine pollutants. Samples of mussels from Central and South America have now been collected and analysed.

Services to international pollution monitoring programmes *(cont.)*

The IAEA-MEL continued to assist Member States to obtain information on the transport and fate of marine pollutants. Of note in 1993 was the continuation of field work and laboratory analyses to assess the impact of oil related pollution in Kuwait and Saudi Arabia stemming from the 1991 Gulf war. IAEA-MEL staff carried out a third pollution survey and collected some fifty samples of sediment, biota and sea water from the surface microlayer; analyses have just begun. Some of the polluted sediment samples have been 'fingerprinted' for oil by inductively coupled plasma mass spectrometry and cold neutron induced prompt gamma multielement analyses through a joint research project between IAEA-MEL and the Japan Atomic Energy Research Institute. Preliminary results suggest that oil related metals such as nickel and vanadium are present in elevated concentrations in the most heavily affected areas.

A main theme of IAEA-MEL's work under this programme is the development and use of nuclear and isotopic techniques to study non-nuclear contaminants. In 1993, radiotracer techniques were developed, within the framework of a co-operative research project sponsored by the CEC, for studying the transfer and fate of pesticides in tropical lagoon systems. In collaboration with the Mazatlan Marine Station of the National Autonomous University of Mexico, an assessment of contamination and cycling of pesticide residues in a coastal lagoon in northwestern Mexico has been completed. In addition, an externally funded, joint research programme for assessing the coastal impact of pesticide residues arising from cotton culture in Nicaragua was initiated with the Research Centre for Aquatic Resources in Managua.

In support of the above mentioned initiatives, a new CRP on the distribution, fate and effects of pesticides on biota in the tropical marine environment was established. This CRP, funded by the Swedish International Development Authority, involves 16 participating countries and will review the usage of pesticides in tropical regions and investigate the fate of pesticide residues through the use of radiolabelled compounds and nuclear techniques.

Monitoring of accidentally released radionuclides in environmental and food samples

Preparation continued of a publication in the IAEA-TECDOC series that will provide Member States with advice on rapid and instrumental separation methods for monitoring radionuclides in food and environmental samples. This document is based on the outcome of a CRP that was concluded in 1992. Support also continued for a new CRP on the development and selection of analytical techniques and procedures for measuring accidentally released radionuclides in the environment.

Laboratory activities

The Agency's Laboratory at Seibersdorf provided substantial support to all of the projects in the subject area, particularly regarding the development and certification of analytical quality control (AQC) materials (IAEA-336 lichen, IAEA-331 spinach and IAEA-359 cabbage in 1993) and all aspects of the project on monitoring radionuclides in food and environmental samples.

In addition to the AQC materials just mentioned, the Laboratory's certification of IAEA-375 soil for ^{129}I was continued, and further work was done on the development and testing of advanced measurement techniques for long lived radionuclides of environmental interest. Through co-operation with laboratories in Member States and participation in CRPs, the needed measurement procedures are transferred to local and national authorities, e.g. a workshop on quality assurance of radioactivity measurements in the Middle East addressed this within a regional project.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1990	Assessment of environmental exposure to mercury in selected human populations as studied by nuclear and other techniques	1994	9
1990	Isotope aided studies of the bioavailability of iron and zinc from human diets	1994	11
1991	Applied research on air pollution using nuclear related analytical techniques	1996	19
1992	Development and selection of analytical techniques and procedures for measuring accidentally released radionuclides in the environment	1996	6

CRPs established in the current year

Subject	No. of years	Participating institutions
Application of stable isotope tracer methods to studies of amino acid, protein and energy metabolism in malnourished populations of developing countries	4	16
Development and application of tracer techniques for studying the behaviour of pesticide residues in the tropical marine environment	4	16

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on nuclear related analytical techniques in air pollution monitoring and research	USA	22	5 weeks
Regional course on isotope techniques in human nutrition research	Ethiopia	19	3 weeks
Regional workshop on quality assurance of radioactivity measurements	United Arab Emirates	22	3 days
Interregional group fellowship course on advanced radiochemical techniques for the monitoring of food and environmental samples	Austria	9	6 weeks
Regional seminar on environmental applications of radiation and isotopes	Chile	79	1 week

Publications

Series and No.	Title
IAEA-TECDOC-683	Development and evaluation of alternative radioanalytical methods, including mass spectrometry for marine materials

INDUSTRY AND EARTH SCIENCES

Programme overview

The Agency's activities in the area of industrial applications of radiation and radioisotopes have focused on methods for minimizing industry related environmental pollution, non-destructive testing (NDT) and nucleonic control systems for on-line mineral analysis. Industrial radiation sterilization has been developed into a major technology with important environmental benefits. Radiation technology for the removal of toxic flue gases from coal fired power stations has reached the pilot scale demonstration level and a model technical co-operation project is to be initiated in 1994. Manpower development in Member States in the area of NDT and other aspects of industrial radiography continued to be emphasized and several regional and national training courses and workshops were organized.

A CRP was initiated late in 1993 on the design and evaluation of heat utilization systems for the high temperature engineering test reactor (HTTR). The object is to select candidate heat utilization systems for potential demonstration at the HTTR.

The main areas of activity in water resources development include:

- *Assessment of water resources, with emphasis on arid and semi-arid regions;*
- *Geothermal resource assessment, with emphasis on high enthalpy fields;*
- *Studies of sediment transport and related problems;*
- *Environmental investigations in the hydrosphere and the atmosphere, including the evaluation of contamination processes and contaminant transport in water bodies;*
- *Analytical and intercalibration services, including the preparation and distribution of standards for isotopic determinations related to hydrology and geochemistry;*
- *Training of scientists from developing countries.*

Work continued in 1993 with field studies and applications in numerous Member States, carried out mainly within the framework of the Agency's technical co-operation programme. A regional programme which involved 13 countries was concluded in Latin America. The applications include water resources assessment and interrelations between surface waters and groundwaters. Another regional programme has been continued in the Middle East, with the main objective being the estimation of water resources under arid and semi-arid conditions.

Two CRPs were completed during 1993. The first shed new light on the role of isotope techniques in the formulation of mathematical models of hydrological systems. The second helped in the evaluation of some geothermal fields in Asia and indicated new lines of investigation for future applications of isotope techniques in geothermal exploration.

The application of isotope techniques to water pollution continued in Latin America through a regional technical co-operation programme. The potential of these techniques in environmental investigations and in water pollution studies was discussed during a symposium and with consultants in Vienna.

The Isotope Hydrology Laboratory continued to provide to Member States analytical and isotope standard services and assistance with the maintenance of equipment. Training was provided to scientists from developing countries, especially through a group course lasting three months.

Owing to a shortfall in financial resources as a result of reductions in the budget, two CRPs on lake and groundwater pollution had to be deferred to 1994. A meeting was convened in 1993 at the request of a Member State on the use of isotope techniques in studying environmental processes in the Caspian Sea region.

INDUSTRIAL APPLICATIONS

Assessment and transfer of radiation technology

It was recommended by consultants that relevant CRPs be initiated in the areas of the conservation of archive materials by the use of gamma radiation, the use of tracer techniques in the study of the deterioration of cultural objects, and archaeometry. This would involve conducting intercomparison studies of different elemental analytical techniques.

Radiotracer applications in the mineral industry

With the co-operation of consultants, work has continued on the finalization of a proposed handbook on nuclear geophysics and modern society. The publication will highlight the many applications of nuclear geophysics in the prospecting and exploitation of oil, gas, water, coal, uranium and other minerals and its role in various endeavours such as earthquake prediction, civil engineering and environmental monitoring.

Nuclear methods for reducing industry related environmental pollution

The first Research Co-ordination meeting of a CRP on nuclear techniques for the evaluation of healing pathways of pollutant damage in the environment was held in Warsaw in June. The aspects being investigated include the healing pathways of chromium, assessment of industrial pollutant species released to the ecosystem of branches of the river Nile, heavy metal pollutants and their speciation, the complexation and distribution of ecologically important metals and metal speciation in high ionic strength waters.

The processing of flue gases and the reduction of the emission of toxic gases to the atmosphere have been the focus of several technical co-operation projects and one CRP. A final Research Co-ordination meeting was held in Poland in May and another meeting was held in Vienna in order to prepare a feasibility study for a large scale industrial project. The programme has been selected as a model project.

Nuclear heat utilization

It was recommended by consultants that a CRP be established on the design and evaluation of heat utilization systems for the high temperature engineering test reactor (HTTR), with the objectives of selecting candidate heat utilization systems which are of international interest for potential demonstration at the HTTR, preparing design concepts and identifying development needs for these systems, and evaluating these systems in terms of safety and the status of the technology.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Development of diagnostic reagents for communicable diseases using radiation processing techniques	1993	6
1988	Radiation processing of combustion flue gases	1993	9
1988	Radiation processing technology applications in bioengineering	1994	10
1989	Nuclear techniques in exploration and exploitation of coal: On-line and bulk analysis and evaluation of potential environmental pollutants in coal and coke	1994	12
1992	Advanced ceramic materials characterization using thermal neutrons	1995	9
1992	Application of nuclear techniques for environment preservation in resource extraction and processing	1995	7
1992	Nuclear methods in monitoring of wear and corrosion in industry	1995	5
1992	Nuclear techniques for the evaluation of healing pathways of pollutant damage in the environment	1995	10
1992	Stability and stabilization of polymers under irradiation	1995	10

CRPs established in the current year

Subject	No. of years	Participating institutions
Design and evaluation of heat utilization systems for the high temperature engineering test reactor	5	6

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on nuclear analytical techniques applied to environmental pollution monitoring	Germany/ Austria	24	4 weeks
Interregional course on nuclear techniques in materials research	France/ Croatia	17	4 weeks
Regional course on application of modern isotope techniques in industry	Australia	20	2 weeks
Regional course on industrial application of non-destructive testing and evaluation	Rep. of Korea	15	3 weeks
Regional course on nuclear techniques in materials development	China	17	4 weeks
Regional course on tracer technology in industry	Mexico	17	3 weeks
Regional workshop on applied aspects of neutron scattering	India	13	3 weeks
Regional workshop on qualification and certification of NDT personnel	Kenya	10	1 week

DEVELOPMENT OF WATER RESOURCES

Development of new methods for the assessment of water resources with isotope techniques

A CRP was completed on mathematical models for the quantitative evaluation of isotope data in hydrology. The results were discussed at the final Research Co-ordination meeting, which took place in Vienna. It was shown that linear lumped parameter models based on input–output isotope concentration variations are usually sufficient to describe hydrological systems. Distributed parameter models, which give a more detailed representation of hydrological systems, require high density spatial and temporal data, which frequently are not available. Models taking into account geochemical reactions along water flow paths are useful for ^{14}C age dating.

The regional project ARCAL XIII, financed by the Government of Germany, was completed. The third regional technical co-ordination meeting was held in Maracaibo, Venezuela, where the main investigators presented the results and conclusions achieved in 14 field projects in 13 Latin American countries. The hydrological systems investigated included: the La Plata aquifer in Argentina, the Cochabamba aquifer in Bolivia, the Chapado do Aripe and Paranà basins in Brazil, the Azapa Valley aquifer in Chile, the Sabana de Bogotá aquifer in Colombia, the Tempisque Valley in Costa Rica, the Jaruco-Aguacate karst aquifer in Cuba, the Rio Guayas Valley and the Chacras-Huaquillas aquifer in Ecuador, the Lake Atitlán and the Guacalate basin in Guatemala, the Comarca Lagunera and Saltillo-Monterey aquifers in Mexico, the Lima aquifer in Peru, the Laguna del Sauce in Uruguay, and Lake Valencia in Venezuela. The projects were related to: surface water and groundwater pollution, the connection between river and aquifer systems, salinization problems, groundwater resource evaluation, groundwater vulnerability to pollution and lake dynamics. The results presented in this meeting will be published in an IAEA-TECDOC.

A regional workshop was held in Damascus, the Syrian Arab Republic, to review and co-ordinate hydrological field investigations carried out with isotope techniques within the framework of a regional technical co-operation project. Also, lectures were given on selected topics related to arid zone hydrology. The areas under investigation include coastal aquifers in Lebanon and the Syrian Arab Republic, a karst aquifer in the Islamic Republic of Iran, aquifers with different characteristics in Jordan and in Turkey, overexploited karst aquifers in the United Arab Emirates, and water movement in the unsaturated zone in Saudi Arabia, the Syrian Arab Republic and Kuwait. All the field studies showed satisfactory progress. The Isotope Laboratory of the Water Authority in Amman, Jordan, provided most of the analytical support to the project, which is now entering its final year.

Studies based on environmental isotopes and tracer techniques continued in the Peruvian altiplano. The scarcity of resources in the coastal areas has forced the local authorities to identify new water sources in the Cordillera and assess their exploitation feasibility. Isotope techniques contributed to the identification of groundwater origin and information about the altitude of recharge and hydrogeological characteristics of several aquifers. In Mongolia, the groundwater resources in the Ulan Bator area were assessed.

Development of new methods for the assessment of water resources with isotope techniques (cont.)

A CRP for Asia and the Pacific, Africa, and the Middle East on the application of isotope and geochemical techniques in geothermal exploration came to an end with the final meeting which took place in Dumaguete, the Philippines. Institutes from 11 countries carried out investigations in low enthalpy geothermal areas on the southeast Asian coast (China and Viet Nam) and on the Korean peninsula (Republic of Korea), in medium enthalpy areas in the Himalayas (India and Pakistan), and in high enthalpy fields in Iceland, Indonesia, Italy, New Zealand, the Philippines and Turkey. The investigations demonstrated that isotope and geochemical techniques are powerful tools in geothermal exploration and have made an important contribution to the assessment of geothermal resources of the countries involved.

A consultants group on isotope techniques in groundwater pollution studies emphasized protection from industrial, agricultural, urban and domestic pollution, and rational (sustainable) exploitation of groundwater resources. The group endorsed the idea that isotope techniques can contribute to the identification of the origin, paths and fate of pollutants in groundwater and to the assessment of the aquifer vulnerability to pollution. The participants discussed in detail the state-of-the-art methodologies for the use of isotopes of nitrogen, sulphur and oxygen in nitrate and sulphate dissolved in groundwater.

Investigations with environmental isotopes have been performed to study the dynamics and flow paths of groundwater in aquifers in Costa Rica and Mauritius. The isotopic investigations permit the identification of the origin and fate of groundwater contaminants. In Mauritius, artificial tracers have also been used. In Uruguay, the transport of pollutants derived from urban sewage in Montevideo Bay was studied using tracer techniques.

The study of the water and pollutant dynamics in Lake Valencia, Venezuela, and in the Buenos Aires bay, Argentina, continued within the framework of a project financed by the German Government. In the third country participating in the project, Ecuador, a new site, the Laguna of Cuyabeno in the Amazon basin, has been selected for a field study. The Laguna is under risk of potential contamination by the oil extraction industry.

An Advisory Group meeting on the application of nuclear techniques in studying soil erosion and siltation was held in Vienna. It was shown that radionuclides such as ^{210}Pb and ^{7}Be (both natural) and ^{137}Cs, ^{239}Pu and ^{240}Pu (all from atmospheric nuclear test fallout) are useful in investigating soil erosion and degradation and sediment accumulation and siltation in lakes and reservoirs.

Isotope techniques have been applied in field projects to study sediment dynamics in Colombia, the Dominican Republic, Romania and Uruguay.

Environmental investigations with isotope techniques

A symposium on the application of isotope techniques in studying past and current environmental changes in the hydrosphere and the atmosphere was held in Vienna. The fields covered were: isotopes in atmospheric studies; isotopes in the soil–plant–atmosphere system; degradation of water resources; palaeohydrology and palaeowaters; and isotope indicators of climatic changes. The symposium demonstrated that isotopes are among the most powerful tools to investigate past environmental and climatic changes and their causes, and these studies could help to formulate hypotheses and predictions of changes in the 21st century.

Analytical and intercalibration services

Consultants discussed the status of stable isotope reference standards and intercomparison samples distributed by the Agency for isotope analyses performed for hydrological, geochemical and environmental studies. The value of a recently prepared standard of silver sulphide was proposed, and the preparation of other new standards was recommended. The recommendation was also made to determine the absolute isotopic ratios of the current reference standards. Full co-operation has been established in this field between the Agency, the Institute for Reference Materials and Measurements of the European Union in Geel, Belgium, and the National Institute of Standards and Technology of the United States Department of Commerce, in Gaithersburg, Maryland.

Within the framework of the technical co-operation programme, assistance and training were provided through the Isotope Hydrology Laboratory to institutions in Member States setting up new laboratory facilities for environmental isotope analysis, or upgrading and strengthening existing facilities. These countries include Algeria, Bulgaria, Ecuador, Greece, Indonesia, the Islamic Republic of Iran, Nicaragua, Paraguay, Turkey and Uruguay.

At the Laboratory, approximately 3500 water samples were analysed for deuterium, 3000 for ^{18}O, 1600 for ^{3}H, 100 for ^{14}C and 150 for ^{13}C, and about 1200 chemical analyses were performed on 190 water samples. In particular, 30 tritium determinations were carried out on water samples collected during safeguards inspection missions to Iraq.

The database for the isotopes in precipitation network has been optimized for more efficient data handling and retrieval, and the statistical treatment of the isotopic and meteorological data has also been included.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1990	Isotopes and geochemistry in geothermal exploration in Africa, Asia and the Pacific, and the Middle East	1993	11
1990	Mathematical models for quantitative evaluation of isotope data in hydrology	1993	10
1991	Isotope variations of carbon dioxide and other trace gases in the atmosphere	1994	12
1992	Application of tracer techniques in the study of processes and pollution in the Black Sea	1995	13
1992	Use of nuclear techniques in palaeoclimatology: Continental isotope indicators of palaeoclimates	1995	14

CRPs established in the current year

Subject	No. of years	Participating institutions
Isotope techniques in lake dynamics investigations	3	5
Isotope techniques in water resource investigations in arid and semi-arid regions	3	2

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on the use of isotope techniques in water resources assessment	Zimbabwe	18	4 weeks
Group training on isotope hydrology	Headquarters	25	3 months

Publications

Series and No.	Title
Proceedings Series	Isotope techniques in the study of past and current environmental changes in the hydrosphere and the atmosphere
IAEA-TECDOC-713	Nuclear techniques in the study of pollutant transport in the environment: Interaction of solutes with geological media
IAEA-TECDOC-721	Les ressources en eau au Sahel: Etudes hydrogéologiques et hydrologiques en Afrique de l'ouest par les techniques isotopiques
IAEA-TECDOC-726	Isotopic and geochemical precursors of earthquakes and volcanic eruptions

PHYSICAL AND CHEMICAL SCIENCES

Programme overview

The Agency's co-ordination of national and regional data centres for nuclear and atomic data continued, ensuring that data measured and evaluated in one country are available to scientists and engineers in all Member States. Improved data centre services were offered through the computerized on-line Nuclear Data Information System (NDIS) and the Atomic and Molecular Data Information System (AMDIS).

Activities to establish atomic and molecular databases for biomedical research continued since there was a need for such data in radiotherapy and for the biophysical modelling of radiation induced damage in subcellular biological substances (in particular DNA).

Over fifty technical co-operation projects on nuclear instrumentation were given support during the year. In order to make the recipient countries self-reliant in nuclear instrument maintenance, national, regional and interregional training courses and workshops were conducted in China, Indonesia, Kenya, Madagascar, Myanmar and Viet Nam. The spare parts provision service for better upkeep of nuclear instruments in Latin America and the Asia and Pacific regions was continued.

The 1993 programme at the ICTP encompassed a range of activities that included research, high level training courses, training at Italian laboratories, conferences, workshops and topical meetings.

Support continued for activities related to the improved operation and utilization of research reactors in Member States, with emphasis on conversion to low enrichment fuels, support of fundamental and applied research programmes and technical issues arising from the continued operation of old reactors. Guidance and advice were given for establishing new research reactors and for upgrading, refurbishing and improving existing facilities.

In chemistry, the focus was on the production of high quality medical radioisotopes, radiopharmaceutical development, in vivo diagnostic kits, radioimmunoassay/immunoradiometric reagents and assay procedures. Technical support was provided for expanding applications of new radiopharmaceuticals for functional studies of the heart and brain, and for SPECT imaging.

NUCLEAR AND ATOMIC DATA FOR APPLICATIONS

Data centre management, co-ordination and services and manpower development in the use of nuclear and atomic data

Significant improvements have been received for the five national/regional major evaluated nuclear data libraries, BROND-2 (Russian Federation), CENDL-2 (China), ENDF/B-6 (USA), JEF-2 (OECD/NEA) and JENDL-3 (Japan), and incorporated into the Agency's database. An improved package of related data processing computer codes was issued. Examples of special purpose data libraries that have been received in the past year are:

- Fission product yield data (Russian Federation and USA);
- Data for 540 charged-particle induced reactions measured in Kazakhstan and compiled by the nuclear data centre in Moscow (Russian Federation);
- A photon-electron interaction database (USA);
- A database on strong gamma rays emitted from radionuclides (Japan).

Progress has been made in the development of the Agency's atomic and molecular/plasma-material interaction (A+M/PMI) database system, ALADDIN, which now operates on an on-line access basis (via INTERNET) and contains about twenty fusion research relevant specific databases. The newly established Atomic and Molecular Data Information System (AMDIS), the continued semi-annual publication of the *International Bulletin on Atomic and Molecular Data for Fusion*, and the regular annual publication of the Agency's *Atomic and Plasma-Material Interaction Data for Fusion* represent the main means by which the available recommended A+M/PMI data information is disseminated to users in the Agency's Member States.

A direct link from the Agency's VAX computer to the international computer network INTERNET was installed to provide improved remote access to the databases. Use of the service has grown in the past year. It is estimated that the rapid growth of electronic computer networks worldwide will lead to an annual doubling of the use of this service over the next few years. All data received are checked, documented and made available to researchers in Member States on magnetic tapes or personal computer diskettes, as printed materials, or through the on-line Nuclear Data Information System (NDIS). All available datafiles and services are advertised in the Agency's *Nuclear Data Newsletter*, of which more than four thousand copies are distributed to nuclear scientists in Member States.

During 1993, the Agency fulfilled about 700 requests from scientists in 75 Member States for experimental and evaluated data and related documentation, data processing codes and publications.

Establishment of improved nuclear data sets for fission reactor technology and safety

A new version of the International Reactor Dosimetry File (IRDF) was issued. This file serves as a standard so that all Member States can use a common methodology for neutron dosimetry in fission and fusion reactors to estimate radiation damage, required shielding, etc.

The IAEA WIMS-D4 nuclear data library update project is designed to replace the current library generated more than twenty years ago with a new library

***Establishment of improved nuclear data sets for fission reactor technology and safety** (cont.)*

based on modern nuclear data evaluations for users of the WIMS-D4 or compatible thermal reactor lattice-cell code in developing countries. The NJOY code system, with the updated WIMSR module, has been successfully used to process the recently released (1992) basic evaluated nuclear data files ENDF/B-VI, JENDL-3.1, BROND-2 and CENDL-2 for a few selected isotopes. Over 23 laboratories from 18 countries have participated in the project. Additional benchmarks validating other isotopes are now being analysed.

Establishment of international reference libraries of nuclear and atomic data for use in fusion reactor technology

A nuclear data library especially designed for fusion applications, FENDL, has been issued in processed form for use by the International Thermonuclear Experimental Reactor (ITER) team in the early phase of its engineering and design activity. Integral testing of this library is in progress so as to validate its quality.

Several new atomic and molecular databases were released, including a recommended database for the collision processes of hydrogen atoms with electrons, protons and multiply charged ions, a similar database for lithium atoms, an evaluated database for the sputtering of fusion relevant materials upon light ion impact, and a database on the light ion particle and energy reflection coefficients from material surfaces. Progress has also been made in the establishment of collisional databases for helium, beryllium, boron and other fusion plasma impurities, of the erosion database for the candidate fusion reactor plasma facing materials, and of the material properties database for beryllium. Consultants have recommended that data libraries be established for tritium retention in fusion reactor plasma facing and structural materials and for atomic and plasma–surface interaction data needed for detailed predictive modelling of fusion plasma disruptions and the associated erosion of reactor wall materials.

Development of reference nuclear databases for nuclear waste incineration, environmentally safe nuclear waste disposal and applications of intermediate energy radiations

Contributions from participants at a CRP on atomic and molecular data for radiotherapy were used in the preparation of a handbook. The handbook contains data on physical processes which take place in human tissues exposed to different types of radiation: photons, neutrons and charged particles. Recommended sets of data needed for dose determination and evaluation of radiation induced effects in tissues at molecular and biological levels are presented. The publication is intended for use by specialists in basic radiation research, dosimetry in tissues (including microdosimetry) and radiation therapy.

In a long term effort, the first version of an international database of activation cross-sections for more than 11 000 reactions of 636 stable and unstable target nuclei was compiled. These data are needed to estimate the induced radioactivity of materials in fission and fusion devices and in other facilities exposed to nuclear radiation.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Atomic and molecular data for fusion edge plasmas	1994	12
1989	Atomic and molecular data for radiotherapy	1993	14
1989	Activation cross-sections for the generation of long lived radionuclides	1995	10
1991	Plasma interaction induced erosion of fusion reactor materials	1995	10
1991	Compilation and evaluation of fission product yield nuclear data	1996	7
1991	Atomic data for medium and high Z impurities in fusion plasmas	1994	10
1992	Improvement of measurements, theoretical computations and evaluations of neutron induced helium production cross-sections	1996	9

CRPs established in the current year

Subject	No. of years	Participating institutions
Establishment of the international reference data library of nuclear activation cross-sections	3	3

Publications

Series and No.	Title
Annual publication	CINDA 93
Technical Reports Series No. 357	Handbook on nuclear data for borehole logging and mineral analysis
Newsletter	Nuclear data newsletter, No. 18
External publication	Atomic and plasma–material interaction data for fusion, supplement, Nuclear Fusion, Vol. 4
External publication	Atomic and molecular data for fusion reactor technology
	Atomic and plasma–material interaction processes in controlled thermonuclear fusion
	International bulletin on atomic and molecular data for fusion, Vols 46 and 47
INDC(NDS)-267	Atomic collision database for Li beam interaction with fusion plasmas
INDC(NDS)-268	Charged particle and photonuclear data libraries for fusion applications
INDC(NDS)-269	Nuclear data requirements for fission reactor decommissioning
INDC(NDS)-272	Measurement and analysis of 14 MeV neutron induced double differential neutron emission cross-sections needed for fission and fusion reactor technology
INDC(NDS)-273	Improvement of measurements, theoretical computations and evaluations of neutron induced helium production cross-sections
INDC(NDS)-277	Atomic and molecular data for fusion reactor technology
INDC(NDS)-279	Co-operation of the Nuclear Reaction Data Centres
INDC(NDS)-280	Report of the IAEA Nuclear Data Section to the International Nuclear Data Committee
INDC(NDS)-281	Neutron multiplication in fusion reactor first wall and blanket materials
INDC(NDS)-282	Standard input data sets for nuclear model computations of nuclear data
INDC(NDS)-286	Activation cross-sections for the generation of long lived radionuclides of importance in fusion reactor technology
INDC(NDS)-287	An evaluated database for sputtering
INDC(SEC)-104	WRENDA 93/94, World Request List for Nuclear Data

NUCLEAR INSTRUMENTATION

Maintenance of nuclear instrumentation

The spare parts provision service to the Latin American and Asia and Pacific regions was continued. Also, a seminar on nuclear instrumentation for research reactors was held under the ARCAL II programme. The technical report to be published from this seminar will assist Member States in equipping their research reactor facilities.

Nuclear spectroscopy

Under the auspices of the ARCAL II programme, a regional workshop was held on the selection and optimization of nuclear analytical equipment. A document in the IAEA-TECDOC series was developed at this workshop to advise Member States on this subject.

The development of computer software for nuclear applications continued, with an improved version of SPEDAC, a program for the transfer and reformatting of spectra, for Microsoft DOS and a new version of SPEDAC for the Microsoft Windows environment. A new software package for neutron activation analysis, ACTAN, was developed and incorporated into the GANAAS (gamma spectrum analysis and neutron activation analysis) code.

To assess the level of expertise of X ray fluorescence (XRF) analytical laboratories and the reliability of the results they produce, an Advisory Group meeting was held on the intercomparison of these laboratories. The methodology to be used in this intercomparison was defined.

Laboratory activities

In addition to the routine in-house service and technical support offered to other units of the Agency's Laboratory at Seibersdorf, technical assistance was provided to establish and/or upgrade infrastructures for the repair and maintenance of nuclear instruments in developing Member States, particularly in the Africa region. The technical support included expert missions, rapid provision of relevant equipment, replacement parts and service manuals. Other special instruments developed with Agency assistance were: a spectrum stabilizer module and an energy dependent area monitoring system.

The Laboratory was also involved in the design and construction of special instruments and training kits. For example, a stack monitoring system for a research reactor in Viet Nam was constructed. This computer based, card mounted system will be used for monitoring gaseous samples containing radioactive particulate, iodine and noble gases released from a reactor stack. Modified complete UNOLAB single channel spectroscopy systems for training in nuclear electronics were prepared in kit form and sent to Colombia and Ethiopia.

A capillary-based X ray microfluorescence system was used for local analysis and elemental mapping of geological materials, coal-rock interfaces, individual air particles and fused glass discs with a spatial resolution of 30 micrometres and detection limits below 1 picogram. Specialized software for scanning, data collection, interpretation and imaging was also developed. A simple chemical preconcentration method was adopted for the total reflection XRF measurements, which resulted in further improvements in the detection limits of this very sensitive analytical technique far below the parts per billion range. A new TXRF unit with a double reflector collimator was purchased and attached to a

Laboratory activities *(cont.)*

dual XRF system for simultaneous measurements with total reflection and conventional secondary target X ray tube excitation. Further progress in the extension of the applicability range of quantitative XRF analysis was also made, including both the fundamental parameter approach and the experimental method for the analysis of inhomogeneous specimens.

Two annual group fellowship training courses in the maintenance of nuclear spectroscopy instruments (48 person-months) and in XRF analysis (15 person-months) were organized at the Laboratory. In addition, a number of individual on the job training courses were hosted in the fields of repair, servicing and design of nuclear instruments, computer interfacing, and methodology and applications of XRF techniques (26 person-months).

Training courses and seminars held

Course name	Location	No. of participants	Duration
Advanced interregional course on nuclear electronics	China	18	13 weeks
Workshop on selection and optimization of nuclear analytical equipment (RLA)	Paraguay	9	3 weeks
Seminar on nuclear instrumentation for research reactors	Argentina	8	1 week

THEORETICAL PHYSICS

Fields of research and training for research

The main fields of research and training for research at the International Centre for Theoretical Physics (ICTP) in 1993 were: fundamental physics and astrophysics (high energy and particle physics, cosmology); condensed matter physics (atomic and molecular physics, materials science, surfaces and interfaces); mathematics (applicable mathematics, algebra, geometry, analysis, mathematical physics); physics and energy (plasma physics, non-conventional energy, nuclear physics); physics and the environment (geophysics, soil physics, aeronomy and radiopropagation); physics of the living state (biophysics); applied physics and high technology (microprocessors, communications, synchrotron radiation, lasers and optical fibres, computational physics).

Funding

The financial agreement with the Italian Government has been renewed up to 31 December 1998 by the Italian Parliament. The implementation of the 1993 programme was made possible through a financial contribution from the Italian Government of $18 000 000. The contributions of the Agency and UNESCO amounted to $1 200 000 and $300 000, respectively.

The Centre also acknowledges, with gratitude, contributions from Sweden (SAREC) $206 249; Italy (CNR) $5556; UNIDO $117 083; Japan $39 120; Brazil (IMPA) $16 000; CEC $465 050; Italy (INFN) $39 952; (ING) $15 625; Spain (CICT) $15 000; Switzerland (ETH, ITU) $80 675; and Turkey (CTBP) $99 979.

Training at Italian laboratories

More than one hundred and fifty scientists from developing countries carried out research at Italian academic and industrial laboratories under a programme which started in 1982 with the financial support of the Direzione Generale per la Cooperazione allo Sviluppo (Italian Ministry for Foreign Affairs, Rome).

External activities

In the fields of physics and pure and applied mathematics, the Centre sponsored 63 activities, courses, workshops and symposia in 29 countries. Affiliated Centres were established in 16 countries and 8 networks were created involving 34 countries; in addition, there were 6 visiting scholars.

Meetings hosted

The Centre hosted 11 meetings. The organizing institutions were the International Centre for Genetic Engineering and Biotechnology, Trieste; the International Centre for Science and High Technology, Trieste; the Third World Academy of Sciences, Trieste; and the universities of Florence and Trieste.

Other meetings

The ICTP Ad hoc Consultative Committee met in April to review the achievements over the past ten years and make recommendations for the future.

The Scientific Council met in May under the Chairmanship of the Nobel Laureate J.R. Schrieffer.

Books and equipment donation programme

In 1993, the Centre was able to distribute 31 985 journals, 6060 proceedings and 261 books to 400 institutions in 70 developing countries. In addition to the donations directly distributed by the Centre, a large number of donations of complete sets of back issues of journals were shipped directly by the donors to institutions in developing countries.

Awards

The 1993 Dirac Medals of the ICTP were awarded to S. Ferrara (Theory Division, CERN, Geneva), D.Z. Freedman (Department of Mathematics, Massachusetts Institute of Technology), and P. van Nieuwenhuizen (Department of Physics, State University of New York at Stony Brook), for their discovery of supergravity theory in 1976 and their major contributions in the subsequent developments of the theory. Their discovery led to an explosion of interest in quantum gravity and it transformed the subject, playing a significant role in very important developments in string theory as well as Kaluza-Klein theory. Currently, any grand unified theory incorporating gravity is based on a supergravity theory coupled to matter in four dimensions, which naturally emerge from the compactifications of the ten dimensional heterotic string.

The 1993 ICTP Prize, in honour of J.R. Schrieffer, was awarded to D. Dhar, Tata Institute of Fundamental Research, Bombay, India, in recognition of his contributions in the field of condensed matter physics.

Preprints and internal reports

In 1993, 437 preprints and internal reports were issued.

Fields of research and training

Fundamental physics

Course name	Total No. of participants	Participants from developing countries	Duration
Research in fundamental physics and astrophysics	177	88	1 year
Diploma course in high energy physics (academic year 1992–1993)	15	14	6 months
Diploma course in high energy physics (academic year 1993–1994)	14	11	4 months
Conference on highlights of particle and condensed matter physics ('Salamfest')	116	52	1 week
Spring school and workshop on string theory, gauge theory and quantum gravity	144	51	2 weeks
Summer School on high energy physics and cosmology	228	151	7 weeks
Third school on non-accelerator particle astrophysics	81	35	2 weeks

Condensed matter, atomic and molecular physics

Course name	Total No. of participants	Participants from developing countries	Duration
Research in condensed matter physics	109	62	1 year
Diploma course in condensed matter physics (academic year 1992–1993)	16	14	6 months
Diploma course in condensed matter physics (academic year 1993–1994)	13	12	4 months
Sixth international workshop on computational condensed matter physics	130	20	3 days
Experimental workshop on high temperature superconductors and related materials (advanced activities)	76	66	3 weeks
Miniworkshop on strongly correlated electron systems	104	46	3 weeks
Research workshop in condensed matter, atomic and molecular physics	270	186	11 weeks
Workshop on the liquid state of matter: Opportunities from new radiation sources	86	13	2 weeks
Miniworkshop on non-linearity: Chaos in mesoscopic systems	73	54	2 weeks
Working party on mechanical properties of interfaces	32	23	2 weeks
Course on geometric phases	58	29	2 weeks
Conference on the origin of life	71	24	1 week

Mathematics

Course name	Total No. of participants	Participants from developing countries	Duration
Research in mathematics	155	76	1 year
Diploma course in mathematics (academic year 1992–1993)	17	11	6 months
Diploma course in mathematics (academic year 1993–1994)	10	10	4 months
Second workshop on functional-analytic methods in complex analysis and applications to partial differential equations	36	12	1 week
Workshop on representation theory of Lie groups	74	51	3 weeks
Workshop on qualitative aspects and applications of non-linear evolution equations	79	55	2 weeks
Conference on variational problems in differential geometry and partial differential equations	82	42	1 week
School on homogenization	36	12	2 weeks
Second workshop on composite media and homogenization	116	45	2 weeks

Physics and energy

Course name	Total No. of participants	Participants from developing countries	Duration
Research in plasma physics	18	12	1 year
Sixth workshop on perspectives in nuclear physics at intermediate energies	134	27	1 week
Technical Committee meeting on alpha particles in fusion research	60	5	1 week
Spring college on plasma physics	104	69	4 weeks
Workshop on materials science and physics of non-conventional energy sources	127	95	4 weeks

Physics and the environment

Course name	Total No. of participants	Participants from developing countries	Duration
Structure and non-linear dynamics of the Earth (earthquake project)	26	6	1 year
Climate and global change group	4	0	1 year
Course on ocean–atmosphere interactions in the tropics	47	32	3 weeks
College on soil physics	55	48	3 weeks
Second workshop on non-linear dynamics and earthquake prediction	61	30	3 weeks

Physics of the living state

Course name	Total No. of participants	Participants from developing countries	Duration
Meeting on intracellular channels, organelles and cell function	164	20	3 days

Applied physics and high technology

Course name	Total No. of participants	Participants from developing countries	Duration
Microprocessors laboratory	10	6	1 year
High temperature superconductivity experimental laboratory	10	7	1 year
Laboratory for lasers and optical fibres	15	8	1 year
Atmospheric physics and radiopropagation laboratory	6	2	1 year
Fourth training college on physics and technology of lasers and optical fibres	87	61	3 weeks
Third ICTP-URSI college on theoretical and experimental radiopropagation physics	54	45	4 weeks
Winter college on optics	98	58	3 weeks
Workshop on the scientific aspects of rural communications in developing countries	49	47	1 week
College on computational physics	107	80	4 weeks
Workshop on telematics	74	61	5 weeks
Management committee meeting of Cost 238 Project (Prospective and Retrospective Ionosphere Modelling in Europe, PRIME)	25	5	4 days
Workshop on off-median phenomena and international reference ionosphere	36	11	4 days
Second school on the use of synchrotron radiation in science and technology: 'John Fuggle Memorial'	82	51	4 weeks
Second conference on lasers in chemistry	71	41	1 week
Seminar on radiowave propagation in tropical regions (with special reference to recent ITU measurements in Africa)	36	26	1 week

Adriatico Research conferences

Course name	Total No. of participants	Participants from developing countries	Duration
Quantum interferometry	85	24	4 days
Strong correlation phenomena at low carrier densities	126	30	1 week
Scattering from surfaces	91	26	4 days
Mesoscopic systems and chaos, a novel approach	101	56	4 days
Vortex fluctuations in superconductors	49	21	4 days

Miscellaneous

Course name	Total No. of participants	Participants from developing countries	Duration
Miscellaneous research	187	123	1 year
Science, high technology and development (lecture series)	14	3	1 year

Publications

Series and No.	Title
IAEA-TECDOC-715	International Centre for Theoretical Physics: Scientific activities in 1992

UTILIZATION OF RESEARCH REACTORS AND PARTICLE ACCELERATORS

Optimization of research reactor operation, utilization and management

Support continued for activities related to the improved operation and utilization of research reactor facilities. Issues examined in particular were the conversion of reactors for operation with low enrichment uranium fuels, better utilization of reactors for fundamental and applied research programmes, and technical issues arising from the continued operation of old research reactors. Training activities focused on research and development programmes using research reactor beam tubes and experimental measurement of research reactor parameters. Guidance and advice continued to be given for establishing new research reactors and for upgrading, refurbishing and improving existing facilities.

Establishment of an accelerator analytical facility

A series of meetings to advise on the use of low energy accelerators continued. This year consultants focused on the application of low energy accelerators in materials research. On the basis of these meetings, a document in the IAEA-TECDOC series is being developed which can be used by Member States who wish to incorporate such accelerators in their national nuclear programmes.

Because the question of an Agency accelerator has been raised often by interested scientists worldwide, an Advisory Group meeting on the establishment of an accelerator facility was held. At this meeting it was concluded that the ready availability of accelerator analytical techniques would be of significant benefit to the Agency in several fields (e.g. safeguards, and environmental and marine analysis). It was recommended that the Agency acquire such a facility — either by installing an accelerator at the Agency's Laboratory at Seibersdorf or by the creation of an Agency beam line on an existing accelerator at a nearby Member State.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1990	Application of personal computers to enhance the operation and management of research reactors	1995	7

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course (RCA) on calculation and measurement of neutron flux spectrum	Indonesia	13	3 weeks
Interregional seminar on research reactor centres — future prospects	Hungary	80	1 week

Publications

Series and No.	Title
Reference Data Series No. 3	Nuclear research reactors in the world, December 1993 edition

CHEMISTRY

Production of new radiopharmaceuticals of $^{99}\text{Tc}^{m}$ and $^{99}\text{Tc}^{m}$ generators from low specific activity ^{99}Mo

Progress was made in a CRP on alternative technologies for $^{99}\text{Tc}^{m}$ generators based on low temperature sublimation and gel elution. Three of the participating groups (from Belarus, Thailand and Viet Nam) were able to standardize the technology for the production of Zr-Mo gel generators for $^{99}\text{Tc}^{m}$, starting with a molybdenum oxide target irradiated at medium neutron fluxes ($\approx 10^{13}$ n·cm^{-2}·s^{-1}). Two participating groups reported progress in preparing high activity $^{99}\text{Tc}^{m}$ generators by irradiating pre-formed Tc-Mo gels in a reactor (up to 5×10^{13} n·cm^{-2}·s^{-1}). A group from Germany reported an attractive method for concentrating dilute solutions of $^{99}\text{Tc}^{m}$ for bolus administration to patients for studies in cardiology, etc.

A new CRP on optimization of the production and quality control of radiotherapeutic radionuclides and radiopharmaceuticals was initiated. Appropriate reactor irradiation strategies using research reactors available in developing Member States for the production of beta emitters such as ^{186}Re, ^{153}Sm and ^{166}Ho, will be developed and optimized. Bone seeking radiopharmaceuticals labelled with these radionuclides will also be investigated with the aim of developing effective radiopharmaceuticals for the relief of bone pain resulting from metastases from breast, prostate and lung cancer.

Biomolecule labelling techniques

The results achieved in a CRP on labelling, quality control and clinical evaluation of monoclonal antibodies for scintigraphy were reviewed at a Research Co-ordination meeting held in Cambridge, United Kingdom. Labelling and quality control protocols, and labelling of the anti-CEA monoclonal antibody were investigated. Labelled antibodies were studied in animals possessing sterile inflammations as well as biodistribution in normal mice. It was concluded that the participants in the CRP are now proficient in labelling monoclonal antibodies with $^{99}\text{Tc}^{m}$.

Indigenous production of reagents for assays of thyroid related hormones

There was progress in the CRP on antibodies immobilized on magnetic particles for radioimmunoassay (RIA) and immunoradiometric (IRMA) hormones. Magnetic particles suitable for immobilization of the first and second antibodies of the thyroid related hormones were prepared by three groups. It was also found that the magnetic separation method can be successfully employed in routine assays of thyroid related hormones and would prove to be a rugged, reliable and cost effective system. The necessary reagents are now available in substantial quantities.

A meeting held in Rabat, Morocco, outlined the actions to be taken to expand the applications of RIA (in a cost effective manner) and streamline the production of RIA reagents and kits at three production centres in Africa (Algeria, Egypt and Morocco) which are at various stages of development. These centres would eventually undertake, on a regular basis, the task of providing these reagents to neighbouring countries in Africa and help to make RIA investigations feasible, more widespread and cost effective in African Member States. The publication of an Agency booklet, entitled *RIA Practice for Africa*, to expand the awareness of the potential of RIA in Africa has also been undertaken.

Laboratory activities

The assistance provided by the Agency's Laboratory at Seibersdorf included the organization of intercomparison studies, distribution of reference materials and training.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Nuclear analytical techniques for trace element analysis in agricultural products and food	1993	11
1990	Labelling, quality control and clinical evaluation of monoclonal antibodies for scintigraphy	1993	13
1990	Evaluation of bulk reagents for production of ^{99}Tc^{m} radiopharmaceutical kits	1993	10
1991	Antibodies immobilized on magnetic particles for radioimmunoassay and immunoradiometric assay of hormones	1994	10
1991	Alternative technologies for ^{99}Tc^{m} generators based on low temperature sublimation and gel elution	1994	10
1992	Optimization of the production and quality control of radiotherapeutic radionuclides and radiopharmaceuticals	1995	10

CRPs established in the current year

Subject	No. of years	Participating institutions
Nuclear analytical techniques in atmospheric and water pollution studies	3	15

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on hospital radiopharmacy	Guatemala	10	3 weeks
Regional course on preparation and control of radiopharmaceuticals	Algeria	14	3 weeks
Regional course on the application of nuclear analytical techniques in pollution studies	Brazil Paraguay	15	3 weeks
Regional workshop on labelling and quality control of biomolecules	Chile	12	2 weeks
Regional workshop on synthesis, kit preparation and quality control of new functional ^{99}Tc^{m} radiopharmaceuticals for SPECT imaging	Turkey	19	12 days

RADIATION SAFETY

Programme overview

The area that attracted the most interest during 1993 in the radiation protection programme was the continued evolution of the new international standards for protection against ionizing radiation and the safety of radiation sources. The development of these new standards, co-sponsored by the Agency, FAO, ILO, OECD/NEA, PAHO and WHO, is being co-ordinated by a joint secretariat including all the co-sponsoring organizations. At the end of the year, a final draft was endorsed at a Technical Committee meeting comprising 127 experts from 52 Member States. It is expected that the governing bodies of the sponsoring organizations will approve the new standards.

Efforts have continued on an integrated programme to incorporate the ideas and concepts from the new standards into the guidelines for the safe transport of radioactive material. The culmination of this work is planned for 1996 with a revised version of the Agency's Transport Regulations.

A joint IAEA–UNDP initiative to strengthen radiation and nuclear safety infrastructures in countries of the former USSR commenced with a forum held in Vienna from 4 to 7 May 1993 which was attended by senior representatives from 13 Republics of the former USSR. Statements were presented outlining the current status of radiation protection and nuclear safety and identifying the areas where improvements as well as international assistance were needed. The proceedings were published in English and Russian in September 1993. The implementation of the joint initiative is planned in three stages: collection of more detailed information through fact finding missions; preparation of country specific programmes; and preparation of assistance packages. Several fact finding missions have already been conducted, namely to Kazakhstan, Kyrgyzstan and Uzbekistan in July 1993, to Estonia and Latvia in October 1993, and to Lithuania in November 1993. On the basis of these missions, country specific programmes are being prepared. Also, a peer review of research reactor safety was conducted in Kazakhstan and Uzbekistan in November 1993 with reference to seismic, nuclear and radiological safety. Another mission went to Kazakhstan and Uzbekistan in November 1993 to provide assistance to the programmes in these two countries on environmental and occupational radiation protection, particularly in the mining and milling of radioactive ores. Also, at the request of the Government of Armenia, a fact finding mission visited the Medzamor nuclear power plant. Follow-up missions are planned to assist in strengthening regulatory infrastructures, seismic analysis and review of the measures for the startup of Unit 2.

A major achievement during the past year was to secure agreement on generic intervention levels in the event of a nuclear accident that will be of direct use to Member States that have not developed their own values. If widely accepted and implemented, these intervention levels will improve harmonization among actions taken by different Member States that can cause widespread public concern and anxiety.

The proposed work on a review of the accident at Kyshtym, the Russian Federation, has not proceeded owing to a shortage of extrabudgetary resources. Most projects on the radiological consequences of the Chernobyl accident also did not commence as the extrabudgetary funds were insufficient. However, the Agency continued to assist in seeking to mitigate the consequences of the disaster at Chernobyl in 1986. One project involved administering a compound called 'Prussian Blue' to cattle in the areas affected by the nuclear fallout from the Chernobyl accident. This compound radically and safely reduces radiocaesium contamination in meat and milk.

BASIC RADIATION SAFETY POLICY

Developing basic principles, criteria and standards for radiation safety

New standards for protection against ionizing radiation and the safety of radiation sources are nearing completion under the sponsorship of six international organizations (the Agency, FAO, ILO, OECD/NEA, PAHO and WHO). The new standards reflect the 1990 recommendations of ICRP Publication 60, as well as subsequent developments. They are drafted in the form of basic radiation safety requirements and are broader in scope and more detailed than the Agency's Basic Safety Standards which were based on the ICRP's 1977 recommendations and published in 1982.

The review of an earlier draft of the new standards at a Technical Committee meeting in December 1992 led to the convening of two working groups in 1993. One of these addressed the issue of controlling exposures to radon in work places other than underground mines, as well as possible variations of the dose limitation requirements in exceptional circumstances. The other working group addressed the limitation of the 'potential exposures' that could occur following unplanned events such as accidents, errors or equipment failures. The recommendations of the working groups were reviewed by the Joint Secretariat and incorporated, along with other modifications, into a fourth draft which was sent to Member States in August for comment. The comments received were incorporated into a fifth draft which was reviewed at a Technical Committee meeting in December 1993. Consensus was reached on all the issues. The resulting sixth draft will be sent to the members of the Technical Committee for confirmation and it is expected that it will subsequently be submitted to the Board of Governors for approval in June 1994.

Education and training in radiation protection

A report, on the implementation of Resolution GC(XXXVI)/RES/584, on a programme for education and training in radiological protection and nuclear safety was prepared and endorsed at the regular session of the General Conference in September. The principal aim of the programme is to strengthen national radiation/nuclear safety infrastructures so that in the long term education and training in the subject areas become self-supporting. The Agency's activities directed towards achieving this goal continue to be based on:

- Education: post-graduate educational courses,
- Training: specialized training courses and workshops,
- Other mechanisms: fellowships, scientific visits, seminars, production of educational and training material.

The courses will be held in English, French, Russian and Spanish. They will be based on a standard syllabus prepared by the Agency. The courses are intended to meet the educational and initial training requirements of junior staff of graduate level or equivalent involved in or designated to take up positions in radiation protection, including health physics. The syllabus is being prepared for publication as a technical document in all of the official languages of the Agency.

Strengthening radiation protection and nuclear safety infrastructures in countries of the former USSR

A joint IAEA-UNDP initiative for strengthening radiation protection and nuclear safety infrastructures in countries of the former USSR was launched with a forum for information exchange in Vienna from 4 to 7 May. Senior officials from 13 countries of the former USSR attended the meeting. The proceedings of the forum were published in English and Russian in September 1993. The second phase of the programme (i.e. preparation of assistance packages for the countries involved) is currently under way. As a follow-up to the forum, fact finding missions to Armenia, Estonia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania and Uzbekistan were conducted during 1993. Fact finding missions to other countries of the former USSR are planned for 1994. For the States visited, country specific assistance packages are being prepared. Presently, limited assistance is being provided; this includes:

- Peer review of research reactor safety covering the areas of seismic, nuclear and radiological safety in Kazakhstan and Uzbekistan;
- Radiological assessment and measurements to identify specific occupational and public exposure problems in Kazakhstan, Kyrgyzstan and Uzbekistan;
- Supply of dosimeters for occupationally exposed individuals.

It is expected that the current phase of the programme will be completed by mid-1994. The third phase of the programme (i.e. implementation of the assistance packages) is dependent on extrabudgetary contributions.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course for radiation protection officers	Ghana	14	3.5 weeks
Regional workshop on the application of the 1990 ICRP recommendations for radiation protection	Malaysia	25	2 weeks
National course for radiation protection officers	Libyan Arab Jamahiriya	19	2 weeks
National course on licensing and inspection for radiation safety	Viet Nam	25	2 weeks
National seminar on radiation protection	United Republic of Tanzania	16	1 week
Regional forum for information exchange under the IAEA-UNDP assistance programme on strengthening radiation and nuclear safety infrastructures in countries of the former USSR	Headquarters	40	4 days
Regional information seminar on application of new ICRP recommendations	Ecuador	20	1 week
Second regional congress on radiation protection and nuclear safety	Mexico	10	1 week
Regional technical meeting on co-ordinated studies on regulatory criteria	Mexico	10	1 week
Interregional course on radiation protection and nuclear safety	Argentina	19	3 weeks

Publications

Series and No.	Title
Special publication	IAEA–UNDP forum on strengthening radiation and nuclear safety infrastructures in countries of the former USSR

OCCUPATIONAL RADIATION PROTECTION

Providing support and guidance for occupational radiation safety

The draft of a joint IAEA–ILO document on occupational protection in the decommissioning and dismantling of nuclear facilities was developed at an Advisory Group meeting. This report was prepared in response to the anticipated increase in decommissioning activities, potentially involving large labour forces consisting of relatively unskilled workers. Clear guidance on issues specifically related to this area is thus of particular concern to the ILO.

An agreement was established between the OECD/NEA and the Agency on co-operation in an information system on occupational exposures (ISOE) to stimulate the exchange of data on methods for the reduction of radiation exposure in nuclear power plants.

A Safety Series report providing guidance on the selection, use, maintenance and training for personal protective equipment used in nuclear facilities is at the final draft stage. It includes comprehensive information on respiratory protection, protective suits, hoods, gloves and boots. The need for this information was highlighted by the experience following the Chernobyl accident. It will be the first Agency document on this topic in over twenty-five years.

Providing support and guidance for workplace and individual monitoring

A publication in the IAEA-TECDOC series summarizing a CRP on intercomparison for individual monitoring was published, providing a clear indication of the impact of the implementation of the new ICRU operational quantities on individual monitoring programmes in Member States. Photon dose conversion coefficients and results obtained from the participants in the CRP provide the information necessary for the selection of calibration phantoms.

The Agency co-operated with the CEC in conducting the first international criticality dosimetry intercomparison in nearly twenty years. Specifically, the Agency supported the participation of three non-CEC Member State institutions from Brazil, India and the Russian Federation. The participants used accident dosimeters and simulated biological dosimetric techniques to evaluate the dose that would have been received by exposed individuals following an accidental criticality. Two neutron fields with different spectral characteristics were provided by the Silene critical facility in France to test the ability of participant institutions to respond rapidly to such an accident.

A document on workplace monitoring and one on personal monitoring have been finalized for publication. They are part of a series that features extensive use of graphics for use in occupational protection training programmes. These documents, which will be available cost free for use in training programmes, will provide simple, illustrative material aimed at technicians and junior professionals. Personal computer based software to test the reader's comprehension of the material in the booklets is under development.

Final drafts of a Safety Series document on dosimetric requirements for individual monitoring for external radiation, and a Technical Reports Series publication on calibration of radiation protection monitoring instruments were prepared. A draft document on the assessment of occupational exposures to

Providing support and guidance for workplace and individual monitoring (cont.)

external irradiation for monitoring purposes was developed for review at an Advisory Group meeting in 1994. A CRP on anatomical, physiological and metabolic characteristics for a Reference Asian Man was completed in 1993. Data on more than 2 000 000 people in nine RCA Member States were compiled for use in more accurate internal dosimetry for Asian populations.

Providing guidance on the assessment and treatment of radiation health effects

The final draft was prepared of a Safety Series publication which provides guidance to the medical community on the assessment and treatment of internal and external contamination as the result of an accident. The document summarizes international experience, including the decontamination measures used in the Chernobyl and Goiânia accidents. In addition, a new document was prepared in the Practical Radiation Safety Manual series on the diagnosis and treatment of radiation injuries. Special attention was paid in this document to the medical management of local skin radiation injuries, which are considered to be the most frequent type of injury in radiation accidents.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1988	Dose per unit intake factors for the public	1993	8
1989	Compilation of anatomical, physiological and metabolic characteristics for a Reference Asian Man	1993	8
1990	The use of natural materials for dose assessment	1993	8
1991	Radiological impact of hot beta particles from the Chernobyl fallout: Risk assessment	1994	13

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on management of occupational exposure to ionizing radiation	USA	32	3 weeks
Regional course on medical preparedness for radiation accidents	Hungary	24	2 weeks
Regional course on clinical dosimetry and radiological protection	Mexico	15	2 weeks

Publications

Series and No.	Title
IAEA-TECDOC-704	Intercomparison of radiation dosimeters for individual monitoring

RADIATION PROTECTION OF THE PUBLIC AND THE ENVIRONMENT

Limiting releases of radioactive materials (including derived intervention levels)

Background work on limiting releases of radioactive materials continued during 1993, but some important work on the methodology for the derivation of release limitations has to await the finalization of the revised standards for protection against ionizing radiation and the safety of radiation sources. The data and the methodology needed for the revision of Safety Series No. 81, on derived intervention levels for application in controlling radiation doses to the public in the event of a nuclear accident or radiological emergency, are being developed with a view to publication of an updated version.

Modelling and monitoring of the environment

A new programme was initiated in 1993 to collect and review environmental monitoring data with the collaboration of UNSCEAR and WHO. As a final product of this programme, a database will be created which will include external radiation levels and radioactivity concentrations in atmospheric aerosols, precipitation, drinking water, groundwater, surface water, sea water, selected bio-indicators and food items under normal conditions.

Assessing radiological impacts on the environment

Further consideration has been given to the establishment of an environmental monitoring database for use in assembling data after a severe nuclear accident. After a review of the quantity, nature and quality of data that resulted from Chernobyl, it was concluded that the setting up of a generalized database structure in advance for a postulated future accident would be extremely difficult and not likely to be of use in a specific event without substantial modification. Given that work is also proceeding on a general environmental database, it was decided not to proceed further with the specific accident related database.

Assessment and control of radon exposures

Preparation of a technical document on the quality assurance of radon measurements has been initiated to help improve the quality of measurements and facilitate the international intercomparability of data.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1990	Radon in the human environment: Instrumentation, modelling, dosimetry and surveys	1994	36
1990	Radon in the human environment: Risk assessment	1994	6

CRPs established in the current year

Subject	No. of years	Participating institutions
Radionuclide transfer parameters in tropical and subtropical environments	4	14

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional workshop on radon monitoring	China	14	2 weeks

Publications

Series and No.	Title
IAEA-TECDOC-698	Generic intervention levels for protecting the public in the event of a nuclear accident or radiological emergency Interim report for comment

SAFE TRANSPORT OF RADIOACTIVE MATERIALS

Maintenance and implementation of the Agency's Transport Regulations

In the review and updating of the Agency's Regulations for the Safe Transport of Radioactive Material, the second Revision Panel meeting addressed many new proposals for changes submitted by Member States. A first draft text, including all agreed changes, was prepared for consideration by Member States.

A Technical Committee meeting was held with the aim of implementing the new ICRP recommendations and the Agency's new standards for protection against ionizing radiation and the safety of radiation sources into the Transport Regulations. The intention is to advance the issue in parallel with the development of the new standards.

New material for general provisions on radiation protection was developed. One of the salient issues was the requirement for the establishment of a radiation protection programme for the transport of radioactive material. Further issues discussed were: the development of a new 'Q-system', providing a new set of A_1 and A_2 values — the maximum quantities of radionuclides in special and non-special form, respectively, that could be released in an accident; the radiation levels around packages (for these no change could be justified); exemption levels for which input from the new safety standards is required; and the need for the establishment of radionuclide specific contamination levels. This last approach was rejected because of its impracticality.

The IMO recently adopted a code for the safe carriage of irradiated nuclear fuel, plutonium and high level radioactive wastes in flasks on board ships. The Code sets standards for the design and construction of ships carrying these materials and was prepared by a Joint IAEA/IMO/UNEP Working Group. During its second session in Vienna, the Working Group considered a number of issues related to accidents at sea, accident statistics, risk studies and emergency response. It was concluded that all the available information demonstrates very low levels of radiological risk and environmental consequences from the marine transport of radioactive material. It was further concluded that there was no evidence to suggest that Agency regulatory test standards are inadequate.

A Technical Committee meeting was convened to address the complicated issue of the transport of low specific activity material and surface contaminated objects (most low and medium level radioactive wastes fall into these categories). The complications arise from the fact that for these categories the activity concentration is the determining factor for the risk, while for other radioactive materials it is the activity. Progress was made in the alignment of the exposure models for low specific activity and surface contaminated objects with those of other radioactive materials, in particular for accident conditions during transport.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Development of probabilistic safety assessment techniques related to the safe transport of radioactive materials	1994	12
1992	Assessment of the safety of UF_6 transport packages in fires	1995	6

Publications

Series and No.	Title
IAEA-TECDOC-702	The air transport of radioactive material in large quantities or with high activity
IAEA-TECDOC-717	Guidelines for safe design of shipping packages against brittle fracture
IAEA-TECDOC-723	Directory of National Competent Authorities' approval certificates for package design, special form material and shipment of radioactive material: 1993 edition

EMERGENCY PLANNING AND PREPAREDNESS

Development and implementation of guidelines for emergency planning and preparedness

A Safety Guide on criteria for intervention after a nuclear or radiation emergency was completed and approved for publication. This document consolidates the work performed and the international consensus reached over the past few years since the Chernobyl accident on principles for intervention and on numerical guidance for the key protective actions that may be instigated following an accident. It was produced after IAEA-TECDOC-698 (on generic intervention levels for protecting the public in the event of a nuclear accident or radiological emergency), which was an interim report for comment. The Safety Guide recommends single generic values for intervention levels for sheltering, evacuation, iodine prophylaxis, temporary relocation, permanent resettlement and food intervention.

A second document is being prepared which describes the procedures and data needed to be able to rapidly assess the significance of an environmental measurement after an accident in terms of the need to take a particular protective action. For example, it will allow measurements of radionuclide concentration on the ground and dose rates to be compared with the intervention level for relocation in order to assist in making decisions about protective action.

A joint document with FAO on agricultural countermeasures after an accident was finalized and made consistent with the Safety Guide on intervention criteria. It contains a taxonomy of options to reduce radionuclide concentrations in foodstuffs by employing agricultural countermeasures, together with a discussion of their advantages and disadvantages with respect to financial costs, practicality, occupational doses, sustainability, etc. The document will serve as a guide for planners and agricultural ministries to develop their own national guidelines for emergency response.

Emergency assistance services

Work continued on improving the capabilities of the Emergency Response Unit and the overall effectiveness of the Agency to respond to a nuclear accident or radiological emergency. The major activities included the following:

— Exercises, drills and training were conducted to maintain a basic response capability. These included: monthly internal communication exercises to test the ability to contact Agency staff and to quickly form a team to respond to the initial notification of a nuclear accident or radiological emergency; periodic external communication exercises involving Member States and other international organizations; periodic Agency staff training, and participation in a nuclear power plant emergency exercise with the United States Nuclear Regulatory Commission.

— An accident at the Tomsk facility in the Russian Federation in March 1993 provided the opportunity for various aspects of the Emergency Response System (ERS) to be used to collect details about the accident and provide this information in a timely manner to the media, Member States and other international organizations.

— Member States' Points of Contact were provided with Information Bulletins and other documents describing various activities related to the Agency's ERS.

Emergency assistance services *(cont.)*

- Member States and other organizations were offered software for decoding any formatted messages that the Agency may send to Points of Contact during an emergency response.

The Agency was an active participant in an OECD/NEA expert group responsible for preparations for the first international exercise on the response to a nuclear accident (INEX-1) conducted in early 1993. This exercise involved 17 countries and was useful in identifying several areas of concern in the international aspects of a response to a nuclear accident.

A document published in the IAEA-TECDOC series (No. 718) provides national authorities with a suggested model to use in the development of a national emergency response plan for radiological accidents. This document was the direct result of missions to developing countries to assist them in establishing their national response plans.

There was continued effort to sustain and upgrade co-ordination and co-operation with other United Nations organizations which would also have a role to play in responding to a nuclear accident or radiological emergency. These activities included:

- A meeting of the Inter-agency Committee for the Response to Nuclear Accidents.
- Participation in the organization and running of WMO's First International Workshop on Users' Requirements for the Provision of Atmospheric Transport Model Products for Environmental Emergency Response. This workshop was useful in establishing stronger arrangements between the Agency and the WMO support centres for the provision of meteorological data and predictions in the event of a release of radioactive material from a nuclear accident.
- Development of operating procedures for the interface between the United Nations Centre for Urgent Environmental Assistance and the Agency's Emergency Response Unit. In addition, work continued with UNEP to utilize its Global Environmental Monitoring System database in planning for the Agency's response to particular accidents at facilities.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on physical protection of nuclear facilities and materials	USA	35	3 weeks

Publications

Series and No.	Title
IAEA-TECDOC-718	A model national emergency response plan for radiological accidents

SAFETY OF RADIATION SOURCES

Design, control and safe use of radiation sources

A CRP on radiation doses in diagnostic radiology and methods for their reduction was completed. Seven Member States participating in a pilot programme on dose reduction were able to achieve reductions of between 30 and 80% in patient entrance dose in radiography. A publication in the IAEA-TECDOC series will be completed by the beginning of 1994.

Provision of information on radiation sources

A review of accidents which have occurred in the field of radiotherapy was carried out. The lessons learned and recommendations to reduce the probability of a recurrence will be included in a publication in the IAEA-TECDOC series in 1994. The accidents studied, some of which resulted in fatalities, together with information gathered by national authorities and professional bodies, identified many problem areas, including errors in the verification of new equipment, sources or treatment planning systems, equipment failures, maintenance errors and essential communication problems. The conclusions and recommendations indicate that quality and safety are inseparable and the quality system has to cover both issues.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1990	Radiation doses in diagnostic radiology and methods for reduction	1993	16

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on safety and regulation of radiation sources	Mexico	27	4 weeks
Regional workshop on radiation protection and quality assurance in diagnostic radiology	Cyprus	13	2 weeks
Sub-regional workshop on control of radiation sources	Guatemala	9	1 week
Workshop on radiation protection and quality control in diagnostic radiology	Zambia	15	1 week
Workshop on radiation protection in X ray examination	Mongolia	25	2 weeks

Publications

Series and No.	Title
IAEA-PRSM-7	Practical Radiation Safety Manual: Self-contained gamma irradiators (categories I and III)
IAEA-PRSM-8	Practical Radiation Safety Manual: Panoramic gamma irradiators (categories II and IV)
Special publication	The radiological accident in Soreq

RADIATION SAFETY SERVICES

Radiation Protection Advisory Team (RAPAT) services

In 1993, RAPAT missions were conducted in Mauritius, Lebanon, Croatia, Kuwait and Myanmar. Efforts continued to be made (e.g. missions to Bangladesh and the United Republic of Tanzania) for an effective and systematic RAPAT follow-up programme with the main purpose of supporting the implementation of RAPAT recommendations. This follow-up was also being done within the framework of relevant regional and national technical co-operation projects. Progress was reported in the development of national infrastructures, including radiation protection legislation (Bangladesh, Ethiopia, Ghana, Madagascar and the United Arab Emirates) and capabilities in providing radiation safety services (Ghana, Jordan, Turkey, the United Arab Emirates and the United Republic of Tanzania).

Laboratory services

The Radiation Protection Laboratory continued to routinely monitor more than 400 Agency staff categorized as radiation workers (external dose exposure and internal contamination monitoring). There were no cases of internal or external overexposure. As in the previous year, all individual doses were maintained far below the annual dose limits.

Individual monitoring services continued to be provided to Member States and co-operation with WHO continued. Approximately 9000 dosimeters were distributed and 1000 finger dosimeters were sent to Member States.

Data from the whole body counter at the Agency's Laboratory at Seibersdorf revealed that general levels of individual internal body burdens of ^{137}Cs have now declined to values observed before the Chernobyl accident. A new laboratory for the chemical radioanalysis of urine samples was completed and is operational.

Radiation protection support was provided to the UNSC 687 Action Team during missions in Iraq. Particular efforts were made during spent fuel removal operations, which are due to continue in early 1994.

RADIOLOGICAL CONSEQUENCES OF THE CHERNOBYL ACCIDENT

Promoting research and development on Chernobyl related issues

Support was continued for the United Nations International Co-operation on Chernobyl. The joint project with FAO on the use of caesium binders for reducing radiocaesium contamination in the milk and meat of grazing animals was implemented on a large scale in the three affected Republics. In Belarus, for example, an investment of around $5000 has led to savings amounting to several thousand times this amount.

A register of projects related to assessing and/or mitigating the radiological consequences of the Chernobyl accident has been established, and co-ordination with WHO and the United Nations International Co-operation on Chernobyl has been strengthened.

SAFETY OF NUCLEAR INSTALLATIONS

Programme overview

Agency efforts continued to develop an international agreement to achieve and maintain a high level of nuclear safety worldwide through national measures and international co-operation. Consensus was achieved on the structure and principal technical obligations of a nuclear safety convention. During 1993, the group of experts met three times in plenary and elaborated a draft text of the convention. The International Nuclear Safety Advisory Group also provided its input and views.

An example of the Agency's efforts to obtain authoritative and accurate open reports about serious nuclear events occurred in connection with the accident in April 1993 at the Tomsk-7 nuclear centre in Siberia, the Russian Federation. Less than 24 hours after the Agency received an invitation to review the situation, three experts left for Siberia to seek first-hand information about the effects of the accident and their consequences for the population and the environment.

The joint IAEA–UNDP initiative on the strengthening of nuclear safety infrastructures and radiation protection in the States of the former USSR is of relevance for safety in research reactors, uranium mining and milling, and facilities using radiation sources in medicine, agriculture and industry. As noted, the first phase of this project — an information exchange Forum — was conducted in Vienna in May 1993. Fact finding missions were then conducted to Armenia, Estonia, Kazakhstan, Kyrgyzstan, Latvia, Lithuania and Uzbekistan. In the second and third phases, assistance packages will be prepared and implemented in individual countries.

The International Nuclear Event Scale (INES) information system continued to be operated for nuclear power plants and on a trial basis for all other nuclear facilities except medical and military facilities. Fifty three countries have so far joined the INES information system. In 1993, 65 events were reported to the system.

Safety fundamentals related to the safety of nuclear installations were agreed by the Board of Governors in June. These fundamentals present an international consensus on the basic concepts underlying the principles for the regulation, management of safety and operation of nuclear installations.

Major efforts are under way to upgrade the safety of nuclear installations in the former USSR and eastern Europe. Assistance is being offered by the G-24 Group of OECD countries, the CEC and WANO. The Agency is focusing its assistance on implementing consistent international safety assessments and on making recommendations regarding the most urgently needed safety improvements. Some improvements in the safety of these facilities have been achieved as a result of the considerable work undertaken by all concerned — mostly, of course, by the countries themselves in the region.

A programme for education and training in nuclear safety and radiological protection was agreed at the regular session of the General Conference in 1993. The principal aim of the programme is to strengthen national radiation/nuclear safety infrastructures, so that in the long term education and training in the subject areas become self-supporting.

An international forum for the exchange of information on current studies related to safety aspects of fusion reactors was held in June in Toronto, Canada.

BASIC NUCLEAR SAFETY PRINCIPLES AND CRITERIA

Principles, criteria and standards for nuclear safety

The International Nuclear Safety Advisory Group (INSAG) continued to advise the Director General in the field of nuclear safety and to consider safety issues important to the nuclear community. A report on a proposed peer review mechanism for a nuclear safety convention, prepared by INSAG, was submitted to the group of experts who are developing the convention. The group is expected to consider the proposal in early 1994. The development of reports by INSAG continued, with work on the safety of older reactors, defence in depth and potential exposures. The three reports are expected to be published in 1995.

An Agency Technical Committee meeting on developments in fusion safety was held in June in Toronto, Canada. The contributed papers covered a broad spectrum of topics, including: the status of national/international developments; safe handling of tritium; operational safety and occupational protection; accident analysis (mainly loss of coolant and loss of flow accidents); selected safety assessment studies; environmental protection issues, particularly tritium releases; licensing of fusion related facilities; and radioactive waste from fusion reactors.

A meeting of senior regulators was held during the regular session of the General Conference. The meeting included senior regulators from over forty countries with nuclear power programmes. The following topics were covered: enhancing safety culture; periodic safety review and relicensing; licensing of a foreign plant; and reporting incidents to the public.

Resolution GC(XXXVII)/RES/615 from the 1993 General Conference urged the group of experts set up by the Director General to continue its work on a nuclear safety convention and stressed the desirability of holding a conference in 1994 on the basis of a comprehensive draft text. The group met three times in 1993 in plenary. Input was also provided by INSAG. The group has reached a consensus on the fundamental principles of nuclear safety which should be adopted as binding international legal obligations of Parties of the convention. Proposals were formulated for a basic mechanism for implementation of the convention, i.e. a peer review process to be conducted through periodic meetings of the Contracting Parties. A seventh meeting of the group is scheduled for January 1994 to reach agreement on the outstanding issues and finalize the draft text. It is envisaged that, as recommended by the General Conference, a conference on the convention can be convened in 1994.

A Safety Fundamentals document on the safety of nuclear installations (Safety Series No. 110) was published in July. It represents an international consensus on the basic concepts underlining the principles for the regulation, management of safety, and operation of nuclear installations.

During the year, the Agency's Nuclear Safety Standards Advisory Group (NUSSAG) reviewed the Safety Fundamentals document on the safety of nuclear installations. Also reviewed was progress on the draft nuclear safety convention and the continued development of the Agency's Regulatory Peer Discussion Groups. As this was the last year of the current NUSSAG term of office, consideration was given to its future and proposed work. It was recommended that NUSSAG should continue, with similar terms of reference, as the Agency's source of expert advice on regulatory matters.

Principles, criteria and standards for nuclear safety (cont.)

The first meeting of a new series of peer discussions was held in November 1993 to consider the policy used for setting and assessing regulatory safety goals. It is intended that different groups of countries will each study the same topic for a series of meetings, placing emphasis on identifying beneficial aspects of practice rather than on comparing regimes. The overall objective is to promote higher standards of nuclear safety through the identification and dissemination of such beneficial aspects.

Enhancing the performance of regulatory bodies and training in nuclear safety

The Agency, at the request of Member States, has continued to organize International Regulatory Review Team (IRRT) missions to carry out peer reviews of regulatory bodies. The purpose is to provide advice and assistance to Member States to strengthen and enhance the effectiveness of their nuclear regulatory bodies, while recognizing the ultimate responsibility of each Member State for the safety of its nuclear installations. In 1993, a review was carried out in Bulgaria at the request of CUAEPP, the Bulgarian regulatory authority. Work is currently in progress to conduct an IRRT mission in China during 1994. In the light of the experience gained and to ensure a consistent approach during IRRT missions, the original guidelines for IRRTs used on the early missions have been revised and they have now been published as IAEA-TECDOC-703.

Publications

Series and No.	Title
IAEA Yearbook	Nuclear safety review 1993
Safety Series No. 110	The safety of nuclear installations
IAEA-TECDOC-703	Guidelines for IAEA International Regulatory Review Teams (IRRTs)

ENGINEERING SAFETY ISSUES FOR NUCLEAR POWER PLANTS

Engineering aspects of site safety: seismic and other external events

The first Research Co-ordination meeting for a benchmark study of the seismic analysis and testing of WWER type nuclear power plants was held in Paks, Hungary. The two prototype nuclear power plants, i.e. Paks (prototype of WWER-440/213) and Kozloduy Units 5/6 (prototype of WWER-1000) were considered in the work plan that was developed at the meeting.

A Technical Committee meeting was organized to review the proposal for the establishment and implementation of a database related to parameters of nuclear power plant sites and design bases for external events. A questionnaire, prepared for data collection, was also reviewed.

Transient and accident analysis

A CRP on the validation of accident and safety analysis methodology was initiated. The aim is to promote research in this area, since power plants cannot be designed, built and/or operated without comprehensive and complex calculations as a part of a new or periodically updated safety analysis report.

Safety aspects of ageing of nuclear power plants

The final draft of a proposed Safety Practices publication on the implementation and review of ageing management programmes for nuclear power plants was prepared. The report provides guidance on the integration of existing operation, maintenance, engineering and research and development programmes into a coherent and effective ageing management programme aimed at maintaining plant safety and reliability. It also outlines guidance on ongoing and periodic reviews of the effectiveness of the related regulatory oversight process.

Development of guidance reports on the assessment of safety margins and residual life of major nuclear power plant components commenced in September. The reports, dealing with specific ageing issues of selected PWR, BWR and CANDU components, are intended to ensure that information on current assessment methods and ageing management techniques is available to all plant operators, regulators, technical support organizations, designers and manufacturers directly and indirectly involved in the operation of nuclear power plants.

Fire safety

A project on fire safety commenced in 1993. The focus has been on the development of a Safety Guide on fire safety inspection in nuclear power plants. In the course of developing this Guide, a Safety Practices document on guidelines for inspection of fire protection and fire fighting techniques for nuclear plants was drafted, reviewed at a Technical Committee meeting and submitted for publication. Another Safety Practices document on guidelines for the evaluation of fire hazard analysis for nuclear power plants was also drafted and reviewed at a Technical Committee meeting in November. A special fire safety mission to the Zaporozhe nuclear power plant in the Ukraine was conducted in August under the Agency's extrabudgetary programme. Fire safety aspects were also investigated during Assessment of Safety Significant Events Team (ASSET) missions to the Kozloduy nuclear power plant in Bulgaria in September, and to the Kola nuclear power plant, Russian Federation, in October. Finally, technical

***Fire safety** (cont.)*

guidance for the conduct of fire hazard reviews was developed with a view to trial application at the Bohunice nuclear power plant. The methodology proposed is based on plant walkdowns and provides a practical approach for evaluating fire hazards. A status report on improving the confinement function was completed.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1992	Management of ageing of in-containment instrumentation and control cables	1995	6
1992	Management of ageing of the concrete containment building	1995	8

Training courses and seminars held

Course name	Location	No. of participants	Duration
Regional course on re-evaluation of seismic safety of nuclear power plants	Hungary	13	2 weeks
Regional workshop on WWER standard problems	Hungary	22	1 week
Regional course on use of the computer code DYN3D/M2	Hungary	10	1 week
National seminar on revision of IAEA Safety Series No. 50-SG-S1	China	50	1.5 weeks
National workshop on seismic instrumentaion at Kozloduy	Bulgaria	20	1 week
National workshop on quality assurance in civil engineering — design and construction for the Chashma nuclear power plant	Pakistan	40	1 week
National workshop on IAEA Safety Series No. 50-SG-D15	Turkey	25	1 week
National workshop on external hazards in nuclear power plant design	Slovakia	20	1 week
Seismic PSA seminar	Bulgaria	18	1 week

Publications

Series and No.	Title
IAEA-TECDOC-724	Probabilistic safety assessment for seismic events

OPERATIONAL SAFETY OF NUCLEAR POWER PLANTS

Application of insights from PSA to operational safety

Plant specific PSA, as an additional tool for assessing the safety of nuclear reactors, is being requested by regulatory bodies worldwide. In some countries, PSAs are requested as a part of periodic safety re-evaluation programmes, while in others they are requested as a generic issue. Some countries are discussing the possible use of PSAs to optimize regulatory activities. A specialists meeting was held in May to discuss the use of PSA in the regulatory process, including the methods and scope of PSA, regulatory review and regulatory applications. It was concluded that there are significant differences between Member States, but the general trend is pointing towards a broader use of PSA in regulation.

Methods and approaches to apply PSA to optimize a variety of operational tasks are being developed in many Member States. A Technical Committee meeting on this topic was held in September in Barcelona, Spain. A document on the use of PSA in optimizing technical specifications and maintenance was prepared. Current problem areas (e.g. acceptance criteria) were also identified and the advantages and disadvantages of absolute versus relative criteria and the prerequisites for broader use of PSA for maintenance optimization were discussed.

A technical document detailing the methodology for risk based optimization of technical specifications was published in 1993. The product of a multi-year international effort, the document includes two pilot studies discussing specific aspects of the use of PSA to optimize technical specifications.

Information on unusual events in nuclear power plants

To date, the Agency's Incident Reporting System (IRS) file contains more than 2150 national reports, though a decreasing reporting rate tendency was observed in 1993. At the beginning of December, 120 events were reported to the IRS. Lack of national resources and language problems were identified by the IRS national co-ordinators as the main reasons for the decrease.

The Agency and the OECD/NEA conducted a joint meeting in Paris in September to discuss activities related to the IRS. The results of IRS topical/generic studies, the main shortcomings of IRS operation, a system proposal for extended computer support of the IRS and a report on findings from recent ASSET missions were some of the topics presented.

Systematic analysis of operational experience

A Technical Committee meeting to review experience with the root cause analysis of incidents was held in Vienna. In addition to papers that were presented and discussed by the participants, the working groups determined which existing methodologies are best suited for the analysis of various event types, and which elements are essential to produce an accurate root cause analysis.

In order to draw lessons from the IRS by analysing those events where single human failures resulted in significant degradation of safety equipment, the Agency carried out a generic study in 1993 covering all incidents, not only maintenance related events. The general conclusion was that the probability of single human failures can be reduced through appropriate measures, but such failures cannot be avoided completely. The safety provisions and possible solutions for

Systematic analysis of operational experience *(cont.)*

corrective actions depend strongly on the particular situation at a nuclear power plant. Examples of the provisions that can be considered to minimize the influence of single human failures on plant safety are: comprehensive task analysis, improvement of work organization and supervision, improvement of content and scheduling of tests, and improvement of procedures.

An IAEA-TECDOC, to be published as a result of a Technical Committee meeting on the review of experience with root cause analysis of incidents, describes the perceived strengths and limitations of some widely used root cause analysis methodologies, including a discussion of lessons learned in the performance of root cause analysis.

Experts from Canada, Finland, France, Germany, Japan, the Russian Federation, Spain, Switzerland and the USA took part in IRS topical studies. The subjects were proposed by national co-ordinators and covered:

— Redundancy, diversity and dependent failures: IRS lessons;
— Compilation of national practices on operational safety experience feedback;
— A compendium on the national actions taken as reported in IRS reports;
— Single human failures resulting in the significant degradation of safety equipment.

Reports on each subject have been issued and some of the topical studies will be finalized in 1994.

Some unusual events at nuclear power plants reported to the IRS were analysed by the ASSET mission to the Khmelninskaya nuclear power plant in Ukraine. This was found to be an effective use of event reports and further steps in this direction will be undertaken.

Advanced computer support for the IRS is under development and will include capabilities to store the full text of IRS reports and to treat textual, numerical and graphical (image) information. In the framework of this activity, development of an IRS thesaurus was initiated.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on operational safety assessment techniques	Spain	25	3 weeks

Publications

Series and No.	Title
IAEA-TECDOC-729	Risk based optimization of technical specifications for operation of nuclear power plants

SAFETY REVIEW SERVICES TO NUCLEAR POWER PLANTS

Operational Safety Review Team (OSART) services

During 1993, there were six Operational Safety Review Team (OSART) missions and five Follow-up Visits. From 1983, when the first OSART mission was conducted, to the end of 1993, 71 missions to 56 power plant sites in 27 Member States had been completed and 23 Follow-up Visits had been made.

Following a pilot review in 1992, safety culture is now being explicitly analysed as an integral part of OSART missions. The questions from the Agency's Safety Series No. 75-INSAG-4, *Safety Culture*, most of which already exist in the OSART Guidelines, are the basis of these reviews. Since safety culture should pervade an organization, it could not be considered as a separate subject. Rather, the reviewers were able to answer the questions from INSAG-4 and assess safety culture in their areas only after interviewing the staff and observing plant activities over the first two weeks of the mission. Safety culture related problems and good practices were reported in the appropriate review areas, and an overall perspective of safety culture was provided in the introduction of the mission report. The process has proved to be effective and the OSART Guidelines have been revised.

OSART/Pre-OSART missions conducted in 1993

Country	Nuclear power plant	Status of plant	Dates
Slovakia	Mochovce	Under construction (Pre-OSART)	11–29 January
France	Gravelines	Operational	15 March–2 April
Romania	Cernavoda	Commissioning (Pre-OSART)	26 April–14 May
China	Guangdong	Commissioning (Pre-OSART)	17 May–4 June
Russian Federation	Smolensk	Operational (safety review mission)	7–18 June
Slovenia	Krško	Operational	5–23 July

Follow-up Visits for OSART/Pre-OSART missions conducted in 1993

Parent mission type	Country	Nuclear power plant	Status of plant	Dates
OSART	South Africa	Koeberg	Operational	29 March–2 April
Safety review	Bulgaria	Kozloduy	Operational	26–30 April
Safety review	Russian Federation	Novovoronezh	Operational	28 June–2 July
OSART	Japan	Fukushima	Operational	25–29 October
OSART	Germany	Grafenrheinfeld	Operational	8–12 November

Assessment of Safety Significant Events Team (ASSET) services

In 1993, 12 ASSET missions were carried out. Six Type R missions, which review the operational safety performance of installations and exchange views on safety management based on effective incident prevention, were carried out at nuclear power plants in the Czech Republic, the Netherlands, the Russian Federation and Ukraine. Each of these two-week missions resulted in a list of recommendations for further measures to prevent incidents at the plants. Type F missions follow up and assess progress made in safety management regarding the prevention of incidents as a result of the implementation of the recommendations of an ASSET Type R mission. Three ASSET Follow-up missions of one week duration and two with a duration of two weeks took place. In general, the ASSET missions found that about 80% of earlier recommendations had been implemented or were well under way. Looking at trends in the severity of events and the effectiveness of surveillance, it was found that there was an improvement in the prevention of incidents. Type A missions review the root cause analysis of a safety significant event in order to disseminate generic recommendations on safety management for the effective prevention of incidents with similar root causes. In November, during a five day ASSET mission, a specific analysis was carried out of an event that occurred at the Paluel nuclear power plant in France in January 1993. The ASSET members concluded that analysis of the event by the plant and the corrective actions taken covered well the direct causes of the event. However, by using root cause analysis, the ASSET was able to make some additional recommendations, addressing policies to create an environment in which incidents are less likely to occur.

ASSET missions conducted in 1993

Country	Nuclear power plant	Plant type	Dates
Ukraine	Khmelnitsky	WWER-1000	8–19 March
Russian Federation	Leningrad	RBMK-1000	17–28 May
Netherlands	Borssele	PWR-480	7–18 June
Russian Federation	Smolensk	RBMK-1000	19–30 July
Czech Republic	Dukovany	WWER-440/213	11–22 October
Ukraine	Rovno	WWER-440/213	22 November–3 December

ASSET Follow-up missions and event analysis

Country	Nuclear power plant	Plant type	Dates
Lithuania	Ignalina	RBMK-1500	1–12 February
Slovakia	Bohunice	WWER-440/230	5–9 July
Bulgaria	Kozloduy	WWER-440/230	20 September–1 October
Russian Federation	Kola	WWER-440/230	4–8 October
Russian Federation	Novovoronezh	WWER-440/230	29 November–3 December
France	Paluel	PWR-130	15–19 November

ASSET training seminars

Country	No. of participants	Duration
Netherlands	30–40	1 week
Ukraine	30–40	1 week
Lithuania	30–40	1 week
Russian Federation	30–40	1 week
South Africa	30–40	3 days
Switzerland	65	1 week

Assessment of Safety Significant Events Team (ASSET) services (cont.)

In June, a Technical Committee meeting on ASSET services took place. The goal of the meeting was twofold: to review ASSET methodology, practices and experience and to make recommendations for further enhancement. The methodology was regarded as giving logical and sound conclusions on the operational safety of the nuclear power plants that have been visited.

In September, consultants involved in the evaluation and assessment of the findings of the ASSET missions to RBMK nuclear power plants produced a set of operational issues and recommendations, together with generic good practices. The recommendations covered:

- Improvement of plant procedures,
- Extension of and improvements in the use of plant specific simulator based training for control room operators,
- Improvement of maintenance programmes and practices,
- The need to further instill in personnel a questioning attitude aimed at constant improvement of all aspects of safety at the plant.

Engineering Safety Review Services related to site and external hazards

Country	Site/plant	Service
Indonesia	Muria Peninsula	Comprehensive review of results for step 2, comparison and ranking of candidate sites
Morocco	Sidi Boulbra	Comprehensive review of site qualification investigations, i.e. final step of siting
Bulgaria	Kozloduy	Review of design for seismic upgrading of Units 1 and 2
Bulgaria	Belene	Interim review of seismic design basis
Pakistan	Chashma	Review of civil engineering design documents
Pakistan	Kanupp	Comprehensive review of the seismic capacity of structures, equipment and distribution systems through a plant walkdown
Slovakia	Bohunice	Interim review of seismic design basis. Interim review of seismic upgrading of Units 1 and 2
Slovakia	Mochovce	Interim review of seismic design basis
Hungary	Paks	Comprehensive review of faulting studies and seismic design basis. Comprehensive review of the seismic capacity of structures, equipment and distribution systems through a plant walkdown

Engineering Safety Review Services related to other topics

Country	Site/plant	Service
Czech Republic	Trebic	Ageing management programme design for WWER-440/213 plant operators
Czech Republic	Prague/Dukovany	Advice on regulatory requirements for the qualification and upgrading of existing instrumentation and control equipment
Czech Republic	Prague/Temelin	Advice on licensing of software based reactor protection systems
Switzerland	Mühleberg	Advice on ageing management programme for Swiss nuclear power plants
Ukraine	Zaporozhe	Advice on fire safety
Slovenia	Ljubljana	Workshop/expert mission on accident management
Pakistan	Islamabad Karachi	Expert mission on severe accidents/accident management for Chashma nuclear power plant (Chinese 600 MW(e) design)
China	Shanghai Chengdu Shingshai	Expert mission for severe accidents/accident management for 300 MW(e) and 600 MW(e) nuclear power plants

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Seismic data for the siting and site revalidation of nuclear facilities	1994	6

CRPs established in the current year

Subject	No. of years	Participating institutions
Benchmark study for the seismic analysis and testing of WWER type nuclear power plants	3	18

MANAGEMENT AND MITIGATION OF ACCIDENTS IN NUCLEAR POWER PLANTS

Accident prevention and mitigation

The MELSIM severe accident simulation trainer is being developed to train nuclear power plant operators. It also evaluates accident management strategies as well as assessing complex interfaces between emergency operating procedures and accident management guidelines. The system is being developed for the WWER-440/213 reactor and is plant specific. The Bohunice V2 power station in Slovakia has been selected for trial operation of the system.

A guidebook on the development of accident management programmes was finalized for publication in the Technical Reports Series. Preparation of a technical document on emergency operating procedures that go beyond the present emergency operating procedures and plant design basis to enhance accident management response capabilities was initiated. These extended procedures, known as accident management procedures to distinguish them from emergency operating procedures, would guide control room staff in terminating the progression of potential severe accidents and in mitigating their consequences, making maximum use of all existing plant equipment, including that which is not part of standard plant safety systems.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Containment integrity and effectiveness for accident conditions beyond design basis	1994	8

Training courses and seminars held

Course name	Location	No. of participants	Duration
Workshop on in-plant accident management	Slovenia	35	2 weeks
National course on severe accident analysis and accident management	China	50	2 weeks

Publications

Series and No.	Title
Technical Reports Series No. 354	Reactivity accidents

RESEARCH REACTOR SAFETY

Development of safety standards for research reactors

Drafts of Safety Guides on the safety assessment of research reactors and preparation of a safety analysis report on safety in the utilization and modification of research reactors have been completed and reviewed by Member States. The drafts have been submitted for publication, which is expected in early 1994.

A CRP initiated in 1989 to collect data and develop a database specific for research reactors was completed in 1993. The final product is a comprehensive database containing the failure rates, failure probabilities and uncertainty bounds for more than 500 component types. The data were collected from 13 different facilities, with a total of more than 18 000 components monitored. The database is accompanied by a guidebook to assist in data collection at other (non-participating) research reactors. The database will be used in several Agency sponsored PSA projects on research reactors.

Implementation of safety standards for research reactors

During 1993, four Integrated Safety Assessment of Research Reactor (INSARR) missions visited research reactors in Greece, Hungary, Kazakhstan and Uzbekistan. In Greece, the GRR-1 research reactor was visited. Several recommendations were made to enhance the overall operation of the facility. In Hungary, the mission reviewed the commissioning programme and implementation of the refurbished 10 MW reactor. In Kazakhstan the mission reviewed a 10 MW research reactor which has been shut down since 1988 over seismic concerns and provided recommendations concerning its restart. In Uzbekistan, the mission reviewed a 10 MW research reactor which is in operation and which will be relicensed in 1995. The last two reviews are part of the programme on strengthening radiation protection and nuclear safety infrastructures in countries of the former USSR.

Incident reporting system for research reactors (IRSRR)

An incident reporting system for research reactors (IRSRR) to collect information on unusual occurrences has been under development. The main purpose of the system is the exchange of research reactor operating experience between the participants in the system. As initial input to the system, a description of all incidents occurring over the last forty years was prepared. The IRSRR will take into account the experience of the IRS for nuclear power plants and will use the same database, but modified for research reactors.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1989	Data acquisition for research reactors, PSA studies	1993	10

APPLICATION OF SAFETY ANALYSIS TECHNIQUES

Conduct and review of probabilistic safety analysis (PSA)

During 1993, there were five International Peer Review Service (IPERS) PSA review missions, two follow-up activities and two pre-reviews. The reviews considered PSAs for nuclear power plants in Hungary, the Republic of Korea, the Netherlands, the Russian Federation and Slovakia; they were conducted by international reviewers from regulatory bodies, operating organizations, consultant companies and nuclear power plant manufacturers. There was an increasing demand for specialized reviews in such areas as: shutdown and low power state PSAs; internal fires and floods and external event PSAs; and level-2 PSAs (accident progression and containment analysis). A major part of the reviews considered the first state-of-the-art PSAs developed currently for the WWER-440/230 and WWER-440/213 nuclear power plants. In one of the follow-up activities, the previous reviews conducted for the Borssele nuclear power plant in the Netherlands at different stages of completion of the PSA were reviewed again to check whether the IPERS recommendations were implemented in the finalized PSA. It was noted that the IPERS reviews had a major influence on the quality of the PSA, thereby strengthening the credibility of the study for applications to safety related plant enhancements.

IPERS reviews in 1993

Review type	Country	Nuclear power plant	Dates
Main review	Slovakia	Bohunice-V1	8–12 March
Pre-review	Hungary	Paks	17–21 May
Specialized review	Netherlands	Borssele	24–28 May
Main review	Hungary	Paks	23 Aug–3 Sept
Pre-review	Republic of Korea	Yonggwang	4–8 October
Specialized review	Netherlands	Dodewaard	18–22 October
Follow-up review	Netherlands	Borssele	1–5 November
Specialized review	Netherlands	Dodewaard	6–10 December
Follow-up review	Russian Federation	Kola-1	13–17 December

A draft document on the safety assessment of shutdown and low power operation presents the methodology for performing a shutdown PSA in an easy to follow, task-like form. In addition, alternative methods, such as barrier analysis and outage safety management, are also described. The document will be submitted for approval to a Technical Committee meeting on shutdown risk assessment to be held in November 1994.

Conduct and review of probabilistic safety analysis (PSA) (cont.)

Plant specific PSAs are under way for most WWER reactor sites. A number of national projects (e.g. Paks PSA, Dukovany PSA) and internationally sponsored projects (Bohunice PSA, Balakovo PSA) were initiated in 1993. All studies follow the standard PSA approach as described in the Agency's Safety Series No. 50-P-4, *Procedures for Conducting Probabilistic Safety Assessments of Nuclear Power Plants*. However, the specific methods used are somewhat different. This issue and the difficulties in using PSA in decision making were discussed during a number of meetings devoted to WWER reactor safety.

Safety impact of human actions

Assessment of Safety Culture in Organizations Team (ASCOT) missions are intended to review the effectiveness of safety culture in an organization in Member States on the basis of the principles and recommendations contained in Safety Series No. 75-INSAG-4, *Safety Culture*. Since its inception, one combined review with OSART (in 1992, to test the methodology), one combined review with ASSET and 12 ASCOT seminars have been held.

In June 1993, an ASCOT representative was added to the ASSET to the Borssele nuclear power plant in the Netherlands to review safety culture within the framework of an ASSET mission.

ASCOT seminars in 1993

Location	Dates
Hungary	22–23 March
Finland	1–2 April
Republic of Korea	15–16 April
Spain	20–21 April
Czech Republic	26–27 April
United Kingdom	24–26 May 26–28 May
Bulgaria	2–4 June
Netherlands (review combined with ASSET mission)	7–18 June
Ukraine	8–9 September
Belgium	8–9 November
South Africa	29–30 November 2–3 December

Reliability of hardware

Reliability data collected at a plant form the basis for a variety of safety studies. A technical document on the establishment of a cost effective data collection and processing system was finalized in 1993. The data collection system described is multi-purpose, i.e. it serves programmes such as PSA, spares management, maintenance optimization and reliability centred maintenance. In addition, a guidelines document on data processing for PSA, which draws on the insights gained from a CRP on reliability data, is being finalized. Specific experience was collected from ten participating countries. This document presents in a concise way the selected data processing methods (both classical and Bayesian statistics) that are needed for development of a comprehensive data set for PSA.

Reliability of hardware
(cont.)

With a number of incidents at nuclear power plants being caused by substandard maintenance, the safety aspects of maintenance are receiving increased attention worldwide. A document was prepared describing various approaches and detailing maintenance optimization methods. It will be published in the Agency's Training Courses Series in early 1994.

The Agency's reliability database continued to be the major source of generic reliability data worldwide. Discussions were held during 1993 to update the database, mainly with plant specific data which are becoming available through PSA studies. Another topic considered was the inclusion of data needed for the reliability of passive components. Equally important is the extension of the database to include common cause failure data.

A Technical Committee meeting held in Vienna in October confirmed new developments in the area of diagnostic systems for nuclear power plants. At the same time, under-utilization of some diagnostic systems was identified, chiefly due to the lack of integration of different systems available to the operator. The integration of diagnostic systems into an overall control system was recognized as a major challenge for the future.

CRPs in progress

Year of start	Subject	Year of completion	Participating institutions
1990	Development of safety related expert systems	1994	13

Training courses and seminars held

Course name	Location	No. of participants	Duration
Interregional course on safety and reliability aspects of maintenance in nuclear power plant operation	USA	32	3 weeks
Interregional course on expert systems and their applications in nuclear power plants	France	25	3 weeks
Regional course on safety related maintenance of nuclear power plants	Russian Federation	24	2 weeks
National seminar on PSA applications	Slovenia	28	1 week
Regional workshop on defining of initiating events for WWERs	Russian Federation	10	1 week
Regional workshop on reliability data	Hungary	26	1 week
National seminar on methodology for external events in PSA	Ukraine	19	1 week
National seminar on basic PSA	Slovakia	25	1 week
National seminar on level 2 PSA	Ukraine	22	2 weeks
Regional seminar on PSA in the regulatory environment	Czech Republic	16	1 week
National seminar on data collection	Ukraine	40	1 week
National workshop on safety optimization of maintenance	Bulgaria	39	1 week
National workshop on use of PSA to optimize operational safety	Mexico	32	1 week
National seminar on PSA methodology	Pakistan	24	1 week

Publications

Series and No.	Title
IAEA-TECDOC-700	The potential of knowledge based systems in nuclear installations
IAEA-TECDOC-711	Use of probabilistic safety assessment for nuclear installations with a large inventory of radioactive material
IAEA-TECDOC-719	Defining initiating events for purposes of probabilistic safety assessment

SAFETY OF FUTURE NUCLEAR POWER PLANTS

Safety aspects, principles and criteria for future nuclear power plants

In response to General Conference Resolutions GC(XXXV)/RES/553 and GC(XXXVI)/RES/582, Advisory Group and Technical Committee meetings were held to prepare the final draft of a document on the development of safety principles for the design of future nuclear power plants. Scheduled to be issued in 1994, this publication in the IAEA-TECDOC series contains a proposal for a self-contained set of objectives and principles. Nearly all established principles as laid down in INSAG-3, *Basic Safety Principles for Nuclear Power Plants*, were found to be also applicable to future plants. Consideration was also given to enlarged objectives related to severe accident situations.

A survey was carried out of existing methods for evaluating the safety of nuclear power plants and to investigate whether there are limitations or problems in using such methods for future nuclear power plants (e.g. lack of data, different role of the operator, etc.). It was felt that additional studies were needed on the use and applicability of severe accident codes, for identification of a complex list of initiating events and accident sequences, and for improvement of PSA methodology for specific parts of future nuclear power plants.

A technical document on the safety aspects of designs for future LWRs (evolutionary reactors) was published. The main purpose of this document is to describe the major innovations of proposed designs of future LWRs and the specific safety characteristics and safety methodologies, and to give a general overview of the most important safety aspects related to future reactors.

Publications

Series and No.	Title
IAEA-TECDOC-712	Safety aspects of designs for future light water reactors (evolutionary reactors)

SAFETY OF NUCLEAR POWER PLANTS BUILT TO EARLIER STANDARDS

Development of a basis for judging the safety of nuclear power plants built to earlier standards

The Agency's conference on the safety of nuclear power, held in September 1991, was the first to deal with the safety of nuclear power plants built to earlier standards. At the 1992 regular session of the General Conference, the Agency was invited to initiate activities in this area. On the basis of experience gained from the extrabudgetary programme on the safety of WWER and RBMK reactors, the Agency began development of a common basis on which the acceptable level of safety of operating nuclear power plants built to earlier standards can be judged. This common procedure will comprise a general policy that is also under consideration by INSAG, as well as a practical approach by means of expert judgement on a case by case basis. Another Technical Committee meeting will be held in 1994 to obtain a broad international consensus on this procedure.

Assessment of the safety of individual nuclear power plants

WWER-440/230 programme. A report was prepared containing a compilation of safety improvements proposed and/or adopted in Bulgaria, the Czech Republic, the Russian Federation and Slovakia in response to safety issues identified by the Agency and other studies. It includes programmes and the status of implementation of safety upgrades of operating WWER-440/230 nuclear power plants. Analyses were made of the completeness, differences and possible discrepancies between the recommendations and plant programmes.

Follow-up missions to assess the status of safety improvements were conducted to the Kozloduy, Bohunice and Novovoronezh nuclear power plants. These missions indicated substantial progress in the implementation of safety improvements.

A document was prepared on guidance for the application of the leak before break concept to WWER-440/230 plants. It also considers international experience in applying the concept. In order to assess the actual safety of the reactor pressure vessels of these nuclear power plants with regard to embrittlement, the Agency is reviewing measures in place at various nuclear power plants, their effectiveness, and additional work required.

In response to a request from the recently established regulatory authority of Slovakia, the Agency reviewed the safety approach underlying the fundamental reconstruction of Bohunice Units 1 and 2. The review concluded that significant safety improvements can be achieved by the proposed backfitting programme.

Assessment of the safety of individual nuclear power plants *(cont.)*

RBMK programme. In June, a meeting was organized in the Russian Federation to review design solutions and proposed safety improvements to the Smolensk Unit 3 RBMK nuclear power plant, the most advanced (third) generation RBMK, which started operation in 1990. The review addressed the following areas: core monitoring and control, component integrity, accident mitigation, support and safety systems, instrumentation and control, seismic safety, fire protection and operational safety. It was found that a number of the safety improvements identified on the basis of the analysis of the Chernobyl accident and other studies have already been incorporated into Smolensk Unit 3.

In order to consider the results of Agency findings and recommendations, a meeting was organized in September. Some sixty safety issues were identified and categorized according to their safety significance as 'high', 'medium' or 'low'. Corrective measures were also prioritized on the basis of their risk reduction impact.

WWER-1000 programme. The major reconstruction programmes for WWER-1000 plants were reviewed. The conclusions of this review have provided important insights into the prioritizations of safety improvements for WWER-1000 nuclear power plants. Upgrading measures for these reactors were also analysed, taking into consideration the underlying safety concerns and the expected safety improvements or risk reductions introduced by the measures proposed. The completeness and adequacy of the upgrading measures relating to the backfitting concept were considered, as well as the applicability of the measures to different WWER-1000 models in operation and under construction.

WWER-440/213 programme. In the framework of a regional technical co-operation programme, assistance is being provided in the area of design basis and beyond design basis accidents. The work is being carried out by task groups in various countries. The aim of the programme is to provide training and facilitate the exchange of information.

A wider programme was initiated to identify the main safety issues and priority actions needed for these reactors so as to provide a common basis against which the proposed improvements in each plant can be evaluated. The programme also includes the resolution of topical safety issues, plant specific safety reviews, including OSARTs and ASSETs, and provision of training for the specialists involved.

A first review of backfitting measures implemented at all WWER-440/213 plants has been compiled on the basis of information from the owners' group. The document specifies the safety improvements proposed and/or implemented, the technical basis and the organization requesting the action (e.g. vendor, utility, or regulatory authority). It will serve as a basis for a major design review evaluation that the Agency will conduct in 1994.

Assessment of the safety of individual nuclear power plants *(cont.)*

International co-operation. The Agency is assisting the G-24 to establish a database on nuclear safety assistance to countries of eastern Europe and the former USSR which should serve as a management tool for the co-ordination of assistance projects. In addition, the Agency is helping with the collection and updating of data — particularly data from national projects — and has provided data from its WWER and RBMK programmes and related technical co-operation projects. In 1993, a methodology was developed for the analysis of gaps and overlaps in assistance activity, coupling the Agency's technical databases on WWER and RBMK reactors with the G-24 Project Data Bank. A procedure for quality analysis of the information included in the G-24 Data Bank was elaborated, and its application is scheduled for 1994.

Publications

Series and No.	Title
IAEA-TECDOC-694	Safety assessment of proposed improvements to RBMK nuclear power plants
IAEA-TECDOC-710	Applicability of the leak before break concept
IAEA-TECDOC-722	Safety assessment of design solutions and proposed improvements to the Smolensk Unit 3 RBMK nuclear power plant

EXAMINATION OF FACILITIES ESTABLISHED UNDER PROJECT AGREEMENTS WITH THE AGENCY

Safety appraisal of facilities established under project agreements with the Agency

The nuclear and radiation safety status of nuclear power plants subject to a project agreement with the Agency is known, as these plants have made use of the services offered by the Agency to all Member States (e.g. OSART and ASSET). In the case of research reactors, the Agency has developed a regular programme to deal with various tasks and responsibilities and continues to implement safety assessments in the form of INSARR missions. In contrast, the current radiological safety status of other facilities, most of which were set up many years ago, is not well documented. A formal programme for the safety assessment of Agency supplied radiation sources has not yet been established. As a result, studies were initiated in this area with a view to establishing the benefits of and need for implementing a programme that would meet the Agency's commitments in connection with existing project agreements as regards the application of health and safety measures. A general strategy was suggested to initially disseminate questionnaires for defining and completing the internal database on this matter, and subsequently to evaluate the responses received through the introduction of a scoring system that will pinpoint the areas where assistance for the improvement of safety would need to be directed.

COMMUNICATION WITH THE PUBLIC

International Nuclear Event Scale (INES)

The INES information system continued to be used for nuclear power plants and on a trial basis for all other nuclear facilities except medical and military installations. Fifty-three countries are committed so far to the use of the INES information system. In 1993, 65 events were reported to the system. Out of these, two level 3 events and six level 2 events occurred at nuclear power plants. Seven of these events were rated under the safety attribute 'degradation of defence in depth'. Only one was rated under the attribute 'on-site impact'. Ten events reported at levels 2 and 3 occurred at other nuclear facilities. One event was rated under the criterion 'off-site impact', five events were rated under 'on-site impact' and four events were attributed to the criterion 'degradation of defence in depth'.

The first INES Advisory Committee meeting took place in March. At the meeting the operation of the INES information system was reviewed on the basis of all events reported to the Agency between October 1992 and March 1993. The events were reviewed for consistency with the INES User's Manual. Additional guidance and classification on a number of issues, particularly related to the trial covering non-reactor events, were proposed. The committee members also emphasized the role of training for proper understanding and application of the manual.

Prior to the annual INES national officers Technical Committee meeting in October 1993, the second Advisory Committee drafted a report for discussion. Additional guidance was prepared, as well as illustrations of the User's Manual based on specific events and the rating of events associated with violation of operational limits and conditions. Again, all events reported to the Agency since the last meeting were reviewed.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Operation and experience of the INES information system	Spain	33	2 days
Rating of the safety significance of events	United Kingdom	18	2 days

SAFEGUARDS

Safeguards statement for 1993

In carrying out the safeguards obligations of the Agency in 1993, the Secretariat did not detect any event which would indicate the diversion of a significant amount of nuclear material or the misuse of facilities, equipment or non-nuclear material which had been placed under Agency safeguards for the manufacture of any nuclear weapon, or for any other military purpose, or for the manufacture of any other nuclear explosive device or for purposes unknown. On the basis of all the information available to the Agency, it is considered reasonable to conclude that, with one exception, the nuclear material and other items which had been placed under Agency safeguards remained in peaceful nuclear activities or were otherwise adequately accounted for.[1] In the case of the Democratic People's Republic of Korea (DPRK), the issues of verification of the initial nuclear material inventory declaration made by it and of the continuous application of full-scope safegards in the DPRK remained unresolved in 1993. Accordingly, the Agency was unable to conclude that there had been no diversion of nuclear material subject to safeguards in the DPRK.

Programme overview

As of 31 December 1993, 194 safeguards agreements were in force with 116 States (and with Taiwan, China), compared to 188 agreements with 110 States (and with Taiwan, China) at the end of 1992.

Safeguards agreements pursuant to the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) entered into force with the Solomon Islands in June, with Tonga in November and with Latvia in December. The safeguards agreement concluded with the Czechoslovak Socialist Republic (INFCIRC/173), which entered into force on 3 March 1972, continues to be applied in the Czech Republic and in the Slovak Republic to the extent relevant to the territory of each of these States. In addition, the NPT safeguards agreement concluded with the Socialist Federal Republic of Yugoslavia (INFCIRC/204), which entered into force on 28 December 1973, continues to be applied in Croatia, in Slovenia and in the Federal Republic of Yugoslavia (Serbia and Montenegro) to the extent relevant to the territory of each of these States.

Two new project and supply agreements with Indonesia, covering the supply of enriched uranium, entered into force in January. A unilateral submission agreement with Pakistan for the application of safeguards to a nuclear power reactor supplied by China entered into force in February.

The trilateral safeguards agreement between India, the USA and the Agency concerning co-operation in the civil uses of atomic energy (INFCIRC/154) expired on 24 October 1993. The Government of India expressed its wish to continue voluntarily the application of safeguards to all nuclear material subject to Agency safeguards under INFCIRC/154, Part I. On 4 October and subsequently on 2 December 1993, the Board of Governors, as interim measures and pending the conclusion of a new bilateral agreement between India and the Agency, approved arrangements under which India and the Agency continued to be bound, until 1 March 1994, by the provisions of INFCIRC/154, Part I, insofar as they relate to the bilateral relationship between India and the Agency.

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[1] The probability of detecting a diversion of nuclear material in an amount less than one significant quantity is lower than that of detecting a diversion of one significant quantity. The probability depends on the amount of nuclear material concerned and the technocal measures and the resources available.

The Board of Governors approved a draft safeguards agreement pursuant to NPT with Armenia. It also approved a project agreement with Colombia covering the supply of enriched uranium. Neither of these agreements had entered into force at the end of 1993. In addition, there were 14 agreements pursuant to NPT, two project agreements, one agreement pursuant to Additional Protocol I to the Treaty of Tlatelolco and an agreement with Argentina, Brazil and the Brazilian-Argentine Agency for Accounting and Control of Nuclear Materials (ABACC), all of which had previously been approved by the Board of Governors but none of which had entered into force at the end of 1993.

During 1993, safeguards were applied in 46 States under agreements pursuant to NPT or to NPT and the Treaty of Tlatelolco, in one State under an agreement pursuant to the Treaty of Tlatelolco and in 9 States under INFCIRC/66/Rev.2-type agreements. Safeguards activities pursuant to NPT in Iraq continued to be subsumed by activities pursuant to Security Council Resolution 687. (The Agency also applies safeguards to nuclear installations in Taiwan, China.)

Voluntary-offer agreements were in force with the five nuclear-weapon States. In all but one State, facilities were designated for inspection. However, owing to financial constraints, it was decided to curtail activities under voluntary offer agreements. Safeguards activities in nuclear-weapon States continued where other obligations existed, e.g. INFCIRC/66/Rev.2-type agreements.

Each State that concludes a comprehensive safeguards agreement with the Agency undertakes to accept "safeguards in accordance with the terms of the agreement, on all source or special fissionable material in all peaceful nuclear activities within the territory of the State, under its jurisdiction or carried out under its control anywhere". Safeguards agreements based on INFCIRC/66/Rev.2 require that safeguards be applied to the nuclear material, facilities, equipment and non-nuclear material — and with regard to certain technological information — specified in them. In the case of nuclear-weapon States, safeguards agreements do not provide for safeguards on all nuclear material, and these States have unsafeguarded nuclear facilities. The Agency believes that there were eight States (nine at the end of 1992) with significant nuclear activities but without any safeguards agreement in force at the end of 1993.

As of 31 December 1993, safeguards agreements pursuant to NPT were in force with 100 States. For 57 non-nuclear-weapon States party to NPT there is still no safeguards agreement in force in accordance with Article III.4 of the Treaty. As far as the Agency is aware, five of these States have significant nuclear activities. Safeguards were being applied in one State pursuant to other safeguards agreements, and technical arrangements are under discussion with the other four States pending the entry into force of a safeguards agreement pursuant to NPT.

NPT safeguards agreements are in force with all 11 signatories of the South Pacific Nuclear Free Zone Treaty (Rarotonga Treaty), and safeguards were applied in one of these States pursuant to such an agreement.

Twenty of the 24 Latin American States party to the Treaty of Tlatelolco have concluded safeguards agreements with the Agency pursuant to that Treaty and 17 of these agreements are in force. Safeguards agreements pursuant to Additional Protocol I of the Treaty of Tlatelolco are in force with two States with territories in the zone of application of the Treaty, and a similar agreement with a third such State has been approved by the Board of Governors, but has not yet entered into force.

The Agency continued its work on the implementation of the safeguards agreement concluded with South Africa. As a result of that work, six Facility Attachments have entered into force since August 1992. The report by the Director General to the General Conference (GC(XXXVII)/1075) concluded that the ^{235}U balance of the material produced by South Africa's pilot enrichment plant is consistent with the uranium feed, that the amounts of HEU which could have been produced by the pilot enrichment plant are consistent with the amounts declared in the initial report, and that efforts by the Agency to clarify apparent discrepancies with respect to the production of LEU at the South African semi-commercial enrichment plant will continue.

In March, the President of South Africa announced that his country had previously developed a limited nuclear deterrent capability and that all nuclear devices produced under that programme had been dismantled and destroyed before South Africa acceded to the NPT. Upon invitation by the Government of South Africa, the Agency sent experts to visit the facilities involved in the abandoned nuclear weapons programme. They also reviewed associated historical data with the purpose of observing that the programme had indeed been terminated and that all the nuclear material used in it had been fully accounted for and placed under Agency safeguards. The report of the experts was submitted to the General Conference in document GC(XXXVII)/1075; it concluded that all the enriched material which has been made available, and produced and processed in connection with the nuclear weapons programme, had been returned to the Atomic Energy Corporation (AEC) and was subject to Agency safeguards at the time of entry into force of the safeguards agreement. The report also concluded that there was no indication to suggest that: (a) substantial amounts of depleted or natural uranium used in the nuclear weapons programme are unaccounted for; and (b) there remain any components of the nuclear weapons programme which have not been either rendered useless or converted to commercial non-nuclear applications or peaceful nuclear usage.

In February, the Board of Governors called upon the Democratic People's Republic of Korea (DPRK) to extend co-operation to the Agency to enable it to fully discharge its responsibilities under its safeguards agreement (INFCIRC/403). The Board also called upon the DPRK to respond positively to the request of the Director General for access to additional information and to sites seemingly related to nuclear waste. Such access had been requested with a view to resolving inconsistencies between the DPRK's initial declaration of its nuclear material subject to safeguards and the Agency's findings. On 12 March the DPRK announced its intention to withdraw from the NPT. As a result of lack of progress over attempts to resolve inconsistencies and to ensure verification of compliance with the safeguards agreement, the Board reported to the United Nations Security Council the DPRK's non-compliance with its safeguards agreement and the inability of the Agency to verify non-diversion. The Security Council called upon the DPRK to reconsider its stated intention to withdraw from the NPT, and to comply fully with its safeguards agreement. The Council also requested the Director General to continue to consult with the DPRK with a view to resolving the issues which were the subject of the findings of the Board of Governors. In June the DPRK suspended the effectuation of its withdrawal from the NPT. After May 1993, only two safeguards inspections of limited scope were permitted at two facilities. The Director General reported on these issues to the General Conference in September and again to the Board of Governors in September and December. These issues were still unresolved at the end of the year.

In April 1993, the Standing Advisory Group on Safeguards Implementation (SAGSI), acting on a request by the Director General, reported its recommendations for a strengthened and more cost effective safeguards system to the Director General. These recommendations focused on a safeguards system characterized by greater transparency and openness (i.e. broader inspector access) and by the implementation of new technical measures designed to enhance the Agency's ability to provide assurances regarding the absence of undeclared nuclear activities in States with comprehensive safeguards agreements. SAGSI further indicated that these measures, in conjunction with an increased level of co-operation with State Systems of Accounting and Control (SSACs), could lead to greater efficiency with respect to the traditional material accountancy system. The Director General reported to the Board of Governors on the SAGSI recommendations in June 1993. The Board requested the Director General to submit to the Board, in December 1993, specific proposals for the assessment, development and testing of the recommended measures.

At the meetings of the Board in December 1993, the Agency's development programme for a strengthened and more cost effective safeguards system was presented. The programme (known as Programme '93+2') provides for the evaluation of the technical, legal and financial implications of the SAGSI recommendations. It was emphasized that the development programme requires a high level of participation by Member States and that any strengthening measures that go beyond the scope of safeguards agreements can be implemented only with the approval of the State or States concerned.

Owing to the 12% cut in 1993 financial plans, the Agency had to reduce certain safeguards activities. The number of inspections for the verification of domestic transfers of depleted, natural and low enriched uranium was again reduced in some cases whereas in other areas it was possible to combine this activity with inspections for other purposes. Inspections in nuclear-weapon States under voluntary-offer agreements were also reduced to a minimum. A significant reduction in funds for technical meetings and travel (both of staff and of outside consultants) hampered the maintenance of contacts among developers of new safeguards equipment and techniques in Member States. A shortage of staff and a scarcity of travel funds also hampered the provision of field support, especially in the area of preventive maintenance of safeguards equipment and implementation of new equipment systems. The release of deferred funds and the provision by several States of extrabudgetary resources for equipment procurement provided some compensation. The shortage of funds during 1993 did not substantially affect training activities, most of which were funded by extrabudgetary contributions.

By Resolution 687, adopted by the United Nations Security Council in April 1991, the Agency was requested to carry out, with the assistance and co-operation of the Special Commission of the United Nations, immediate on-site inspection of Iraq's nuclear capabilities; to develop and carry out a plan for the destruction, removal or rendering harmless, as appropriate, of all nuclear weapons and nuclear-weapons-usable material and any subsystems or components or any research, development, support or manufacturing facilities related thereto; and to develop for the approval of the Security Council a plan for the future ongoing monitoring and verification of Iraq's compliance with its obligations under Resolution 687.

During 1993, the Agency carried out six inspections in Iraq, bringing the total number of inspections to 22. The Agency continued to carry out activities related to the destruction, removal and rendering harmless of items requiring such action pursuant to Resolution 687. The remaining action in that regard, the removal of spent fuel from Iraq, was begun under a contract with the Russian Ministry for Atomic Energy. The first shipment of 108 fuel assemblies out of Iraq for processing and storage in the Russian Federation was completed in December.

The Agency continued to phase in elements of the Agency's plan, approved by the Security Council in Resolution 715, for the future ongoing monitoring and verification of Iraq's compliance with Security Council Resolutions 687 and 707. On 26 November 1993, following a series of high level talks between Iraq, on the one hand, and the Agency and the United Nations Special Commission on the other hand, the Government of Iraq announced its decision "to accept the obligations set forth in Resolution 715, and to comply with the provisions of the plans for monitoring and verification as contained therein". The Government of Iraq also disclosed information related to foreign suppliers of equipment, material and technical advice which had been used in activities prohibited subsequently under Resolution 687, previously a substantial point of contention. The Agency is in the process of verifying the information provided.

Number of States having significant nuclear activities at the end of the year indicated

	Number of States		
	1991	*1992*	*1993*
States with safeguards applied under NPT or NPT/Tlatelolco agreements	*43*	*45*[a]	*47*[a, b]
States with safeguards applied under Tlatelolco agreements	*1*	*1*	*1*
States with safeguards applied under INFCIRC/66/Rev.2-type agreements[c]	*8*	*8*	*8*
Nuclear-weapon States with safeguards applied under voluntary-offer agreements	*4*	*5*	*5*
States without any safeguards agreement in force	—	*9*	*8*
Total number of States with significant nuclear activities	*57*	*68*	*69*

[a] *This excludes Iraq, where safeguards activities in 1993 continued to be subsumed by activities carried out pursuant to Security Council Resolution 687.*

[b] *This includes Latvia, where a safeguards agreement pursuant to NPT entered into force in December but no inspections took place.*

[c] *Some States with INFCIRC/66/Rev.2-type agreements which have not yet been suspended, although NPT agreements have entered into force, are listed under NPT agreements only. Nuclear-weapon States with INFCIRC/66/Rev.2-type agreements in force are not included. Safeguards are also applied to nuclear installations in Taiwan, China.*

Situation on 31 December 1993 with respect to the conclusion of safeguards agreements between the Agency and non-nuclear-weapon States in connection with NPT

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] (1)	Date of ratification, accession or succession[a] (2)	Safeguards agreement with the Agency (3)	INFCIRC (4)
Afghanistan	4 February 1970	In force: 20 February 1978	257
Albania	12 September 1990		
Antigua and Barbuda[b]	1 November 1981	Signed: 1 February 1990	
Armenia	15 July 1993	Signed: 30 September 1993	
Australia	23 January 1973	In force: 10 July 1974	217
Austria	27 June 1969	In force: 23 July 1972	156
Azerbaijan	22 September 1992		
Bahamas	10 July 1973		
Bahrain	3 November 1988		
Bangladesh	27 September 1979	In force: 11 June 1982	301
Barbados	21 February 1980		
Belarus	22 July 1993		
Belgium	2 May 1975	In force: 21 February 1977	193
Belize	9 August 1985	Signed: 13 August 1992	
Benin	31 October 1972		
Bhutan	23 May 1985	In force: 24 October 1989	371
Bolivia[b]	26 May 1970	Signed: 23 August 1974	
Botswana	28 April 1969		
Brunei Darussalam	25 March 1985	In force: 4 November 1987	365
Bulgaria	5 September 1969	In force: 29 February 1972	178
Burkina Faso	3 March 1970		
Burundi	19 March 1971		
Cambodia	2 June 1972		
Cameroon	8 January 1969	Signed: 21 May 1992	
Canada	8 January 1969	In force: 21 February 1972	164
Cape Verde	24 October 1979		
Central African Republic	25 October 1970		
Chad	10 March 1971		
Colombia	8 April 1986		
Congo	23 October 1978		
Costa Rica[b]	3 March 1970	In force: 22 November 1979	278
Côte d'Ivoire	6 March 1973	In force: 8 September 1983	309
Croatia[c]	29 June 1992	In force: 28 December 1973	204
Cyprus	10 February 1970	In force: 26 January 1973	189
Czech Republic[d]	1 January 1993	In force: 3 March 1972	173
Democratic People's Republic of Korea	12 December 1985	In force: 10 April 1992	403
Denmark[e]	3 January 1969	In force: 21 February 1977	193
Dominica	10 August 1984		
Dominican Republic[b]	24 July 1971	In force: 11 October 1973	201
Ecuador[b]	7 March 1969	In force: 10 March 1975	231

Table (cont.)

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] *(1)*	*Date of ratification, accession or succession*[a] *(2)*	*Safeguards agreement with the Agency (3)*	*INFCIRC (4)*
Egypt	*26 February 1981*	*In force: 30 June 1982*	*302*
El Salvador[h]	*11 July 1972*	*In force: 22 April 1975*	*232*
Equatorial Guinea	*1 November 1984*	*Approved by the Board, June 1986*	
Estonia	*31 January 1992*	*Approved by the Board, Feb.1992*	
Ethiopia	*5 February 1970*	*In force: 2 December 1977*	*261*
Fiji	*14 July 1972*	*In force: 22 March 1973*	*192*
Finland	*5 February 1969*	*In force: 9 February 1972*	*155*
Gabon	*19 February 1974*	*Signed: 3 December 1979*	
Gambia	*12 May 1975*	*In force: 8 August 1978*	*277*
Germany[f]	*2 May 1975*	*In force: 21 February 1977*	*193*
Ghana	*5 May 1970*	*In force: 17 February 1975*	*226*
Greece[g]	*11 March 1970*	*Accession: 17 December 1981*	*193*
Grenada	*19 August 1974*		
Guatemala[h]	*22 September 1970*	*In force: 1 February 1982*	*299*
Guinea	*29 April 1985*		
Guinea-Bissau	*20 August 1976*		
Guyana	*19 October 1993*		
Haiti[h]	*2 June 1970*	*Signed: 6 January 1975*	
Holy See	*25 February 1971*	*In force: 1 August 1972*	*187*
Honduras[h]	*16 May 1973*	*In force: 18 April 1975*	*235*
Hungary	*27 May 1969*	*In force: 30 March 1972*	*174*
Iceland	*18 July 1969*	*In force: 16 October 1974*	*215*
Indonesia	*12 July 1979*	*In force: 14 July 1980*	*283*
Iran, Islamic Republic of	*2 February 1970*	*In force: 15 May 1974*	*214*
Iraq	*29 October 1969*	*In force: 29 February 1972*	*172*
Ireland	*1 July 1968*	*In force: 21 February 1977*	*193*
Italy	*2 May 1975*	*In force: 21 February 1977*	*193*
Jamaica[h]	*5 March 1970*	*In force: 6 November 1978*	*265*
Japan	*8 June 1976*	*In force: 2 December 1977*	*255*
Jordan	*11 February 1970*	*In force: 21 February 1978*	*258*
Kenya	*11 June 1970*		
Kiribati	*18 April 1985*	*In force: 19 December 1990*	*390*
Korea, Republic of	*23 April 1975*	*In force: 14 November 1975*	*236*
Kuwait	*17 November 1989*		
Lao People's Democratic Republic	*20 February 1970*	*Signed: 22 November 1991*	
Latvia	*31 January 1992*	*In force: 21 December 1993*	*434*
Lebanon	*15 July 1970*	*In force: 5 March 1973*	*191*
Lesotho	*20 May 1970*	*In force: 12 June 1973*	*199*
Liberia	*5 March 1970*		
Libyan Arab Jamahiriya	*26 May 1975*	*In force: 8 July 1980*	*282*
Liechtenstein	*20 April 1978*	*In force: 4 October 1979*	*275*
Lithuania	*23 September 1991*	*In force: 15 October 1992*	*413*
Luxembourg	*2 May 1975*	*In force: 21 February 1977*	*193*
Madagascar	*8 October 1970*	*In force: 14 June 1973*	*200*
Malawi	*18 February 1986*	*In force: 3 August 1992*	*409*

Table (cont.)

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] *(1)*	*Date of ratification, accession or succession*[a] *(2)*	*Safeguards agreement with the Agency* *(3)*	*INFCIRC* *(4)*
Malaysia	5 March 1970	In force: 29 February 1972	182
Maldives	7 April 1970	In force: 2 October 1977	253
Mali	10 February 1970		
Malta	6 February 1970	In force: 13 November 1990	387
Mauritania	26 October 1993		
Mauritius	25 April 1969	In force: 31 January 1973	190
Mexico[b]	21 January 1969	In force: 14 September 1973	197
Mongolia	14 May 1969	In force: 5 September 1972	188
Morocco	27 November 1970	In force: 18 February 1975	228
Mozambique	4 September 1990		
Myanmar	2 December 1992		
Namibia	2 October 1992		
Nauru	7 June 1982	In force: 13 April 1984	317
Nepal	5 January 1970	In force: 22 June 1972	186
Netherlands[h]	2 May 1975	In force: 21 February 1977	193
New Zealand	10 September 1969	In force: 29 February 1972	185
Nicaragua[b]	6 March 1973	In force: 29 December 1976	246
Niger	9 October 1992		
Nigeria	27 September 1968	In force: 29 February 1988	358
Norway	5 February 1969	In force: 1 March 1972	177
Panama[b]	13 January 1977	Signed : 22 December 1988	
Papua New Guinea	25 January 1982	In force: 13 October 1983	312
Paraguay[b]	4 February 1970	In force: 20 March 1979	279
Peru[b]	3 March 1970	In force: 1 August 1979	273
Philippines	5 October 1972	In force: 16 October 1974	216
Poland	12 June 1969	In force: 11 October 1972	179
Portugal[i]	15 December 1977	Accession: 1 July 1986	193
Qatar	3 April 1989		
Romania	4 February 1970	In force: 27 October 1972	180
Rwanda	20 May 1975		
St. Kitts and Nevis	22 March 1993		
St. Lucia	28 December 1979	In force: 2 February 1990	379
St. Vincent and the Grenadines	6 November 1984	In force: 8 January 1992	400
Samoa	17 March 1975	In force: 22 January 1979	268
San Marino	10 August 1970	Approved by the Board, Feb.1977	
São Tome and Principe	20 July 1983		
Saudi Arabia	3 October 1988		
Senegal	17 December 1970	In force: 14 January 1980	276
Seychelles	12 March 1985		
Sierra Leone	26 February 1975	Signed: 10 November 1977	
Singapore	10 March 1976	In force: 18 October 1977	259
Slovak Republic[j]	1 January 1993	In force: 3 March 1972	173
Slovenia[k]	7 April 1992	In force: 28 December 1973	204
Solomon Islands	17 June 1981	In force: 17 June 1993	420
Somalia	5 March 1970		

Table (cont.)

Non-nuclear-weapon States which have signed, ratified, acceded to or succeeded to NPT[a] *(1)*	*Date of ratification, accession or succession*[a] *(2)*	*Safeguards agreement with the Agency (3)*	*INFCIRC (4)*
South Africa	*10 July 1991*	*In force: 16 September 1991*	*394*
Spain	*5 November 1987*	*Accession: 5 April 1989*	*193*
Sri Lanka	*5 March 1979*	*In force: 6 August 1984*	*320*
Sudan	*31 October 1973*	*In force: 7 January 1977*	*245*
Suriname[b]	*30 June 1976*	*In force: 2 February 1979*	*269*
Swaziland	*11 December 1969*	*In force: 28 July 1975*	*227*
Sweden	*9 January 1970*	*In force: 14 April 1975*	*234*
Switzerland	*9 March 1977*	*In force: 6 September 1978*	*264*
Syrian Arab Republic	*24 September 1969*	*In force: 18 May 1992*	*407*
Thailand	*7 December 1972*	*In force: 16 May 1974*	*241*
Togo	*26 February 1970*	*Signed: 29 November 1990*	
Tonga	*7 July 1971*	*In force: 18 November 1993*	*426*
Trinidad and Tobago[b]	*30 October 1986*	*In force: 4 November 1992*	*414*
Tunisia	*26 February 1970*	*In force: 13 March 1990*	*381*
Turkey	*17 April 1980*	*In force: 1 September 1981*	*295*
Tuvalu	*19 January 1979*	*In force: 15 March 1991*	*391*
Uganda	*20 October 1982*		
United Republic of Tanzania	*7 June 1991*	*Signed: 26 August 1992*	
Uruguay[b]	*31 August 1970*	*In force: 17 September 1976*	*157*
Uzbekistan	*7 May 1992*		
Venezuela[b]	*26 September 1975*	*In force: 11 March 1982*	*300*
Viet Nam	*14 June 1982*	*In force: 23 February 1990*	*376*
Yemen, Republic of	*1 June 1979*		
Yugoslavia (Serbia and Montenegro)[c], *Federal Republic of*	*3 March 1970*	*In force: 28 December 1973*	*204*
Zaire	*4 August 1970*	*In force: 9 November 1972*	*183*
Zambia	*15 May 1991*		
Zimbabwe	*26 September 1991*		

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[a] *The information reproduced in columns (1) and (2) was provided to the Agency by depository Governments of NPT, and an entry in column (1) does not imply the expression of any opinion on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers. The table does not contain information relating to the participation of Taiwan, China, in NPT.*

[b] *The relevant safeguards agreement refers to both NPT and the Treaty of Tlatelolco.*

[c] *The NPT safeguards agreement concluded with the Socialist Federal Republic of Yugoslavia (INFCIRC/204), which entered into force on 28 December 1973, continues to be applied in Croatia to the extent relevant to the territory of Croatia.*

[d] *The NPT safeguards agreement concluded with the Czechoslovak Socialist Republic (INFCIRC/173), which entered into force on 3 March 1972, continues to be applied in the Czech Republic to the extent relevant to the territory of the Czech Republic.*

[e] *The NPT safeguards agreement with Denmark (INFCIRC/176), in force since 1 March 1972, has been replaced by the agreement of 5 April 1973 between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency (INFCIRC/193) but still applies to the Faroe Islands. Upon Greenland's secession from EURATOM as of 31 January 1985, the Agreement between the Agency and Denmark (INFCIRC/176) re-entered into force as to Greenland.*

[f] *The NPT safeguards agreement of 7 March 1972 concluded with the German Democratic Republic (INFCIRC/181) is no longer in force with effect from 3 October 1990, on which date the German Democratic Republic acceded to the Federal Republic of Germany.*

[g] *The application of Agency safeguards in Greece under the agreement INFCIRC/166, provisionally in force since 1 March 1972, was suspended on 17 December 1981, on which date Greece acceded to the agreement of 5 April 1973 (INFCIRC/193) between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency.*

[h] *An agreement had also been concluded in respect of the Netherlands Antilles (INFCIRC/229). This agreement entered into force on 5 June 1975.*

[i] *The NPT safeguards agreement with Portugal (INFCIRC/272), in force since 14 June 1979, was suspended on 1 July 1986, on which date Portugal acceded to the agreement between the non-nuclear-weapon States of EURATOM, EURATOM and the Agency of 5 April 1973 (INFCIRC/193).*

[j] *The NPT safeguards agreement concluded with the Czechoslovak Socialist Republic (INFCIRC/173), which entered into force on 3 March 1972, continues to be applied in the Slovak Republic to the extent relevant to the territory of the Slovak Republic.*

[k] *The NPT safeguards agreement concluded with the Socialist Federal Republic of Yugoslavia (INFCIRC/204), which entered into force on 28 December 1973, continues to be applied in Slovenia to the extent relevant to the territory of Slovenia.*

[l] *The NPT safeguards agreement concluded with the Socialist Federal Republic of Yugoslavia (INFCIRC/204), which entered into force on 28 December 1973, continues to be applied in the Federal Republic of Yugoslavia (Serbia and Montenegro) to the extent relevant to the territory of the Federal Republic of Yugoslavia (Serbia and Montenegro).*

Situation on 31 December 1993 with respect to the conclusion of safeguards agreements between the Agency and States party to the Treaty of Tlatelolco[a]

States party to the Treaty of Tlatelolco (1)	*Date of becoming a party to the Treaty of Tlatelolco* (2)	*Safeguards agreement with the Agency* (3)	*INFCIRC* (4)
Antigua and Barbuda[b]	*11 October 1983*	*Signed: 1 February 1990*	
Bahamas	*26 April 1977*		
Barbados	*25 April 1969*		
Bolivia[b]	*18 February 1969*	*Signed: 23 August 1974*	
Colombia	*6 September 1972*	*In force: 22 December 1982*	*306*
Costa Rica[b]	*25 August 1969*	*In force: 22 November 1979*	*278*
Dominican Republic[b]	*14 June 1968*	*In force: 11 October 1973*	*201*
Ecuador[b]	*11 February 1969*	*In force: 10 March 1975*	*231*
El Salvador[b]	*22 April 1968*	*In force: 22 April 1975*	*232*
Grenada	*20 June 1975*		
Guatemala[b]	*6 February 1970*	*In force: 1 February 1982*	*299*
Haiti[b]	*23 May 1969*	*Signed: 6 January 1975*	
Honduras[b]	*23 September 1968*	*In force: 18 April 1975*	*235*
Jamaica[b]	*26 June 1969*	*In force: 6 November 1978*	*265*
Mexico[b, c]	*20 September 1967*	*In force: 14 September 1973*	*197*
Nicaragua[b]	*24 October 1968*	*In force: 29 December 1976*	*246*
Panama[d]	*11 June 1971*	*In force: 23 March 1984*	*316*
Paraguay[b]	*19 March 1969*	*In force: 20 March 1979*	*279*
Peru[b]	*4 March 1969*	*In force: 1 August 1979*	*273*
St. Vincent and the Grenadines[e]	*11 May 1992*		
Suriname[b]	*10 June 1977*	*In force: 2 February 1979*	*269*
Trinidad and Tobago[b]	*27 June 1975*	*In force: 4 November 1992*	*414*
Uruguay[b]	*20 August 1968*	*In force: 17 September 1976*	*157*
Venezuela[b]	*23 March 1970*	*In force: 11 March 1982*	*300*

In addition, there are the following safeguards agreements with States party to Additional Protocol I to the Treaty[f]:

Netherlands[b]	*In force: 5 June 1975*	*229*
United Kingdom	*Approved by the Board, Sep 1992*	
United States of America	*In force: 6 April 1989*	*366*

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[a] *The information reproduced in columns (1) and (2) was taken from the relevant OPANAL status report.*

In addition to the States listed in column (1), Argentina has signed the Treaty but not ratified it, while Brazil and Chile have ratified it but have not yet become parties to the Treaty as they have not so far made the declaration provided for in Article 28 of the Treaty. Dominica signed the Treaty on 2 May 1989, Belize signed the Treaty on 14 February 1992 and St. Lucia did so on 25 August 1992.

[b] *The relevant safeguards agreement refers to both the Treaty of Tlatelolco and NPT.*

[c] *The application of safeguards under an agreement with Mexico in connection with the Treaty of Tlatelolco which entered into force on 6 September 1968 (INFCIRC/118) was suspended after the conclusion of an agreement with Mexico in connection with both the Treaty of Tlatelolco and NPT (INFCIRC/197).*

[d] *An agreement has also been concluded in 1988 pursuant to both the Treaty of Tlatelolco and NPT; this has not yet entered into force.*

[e] *Safeguards agreement pursuant to NPT in force (INFCIRC/400).*

[f] *Additional Protocol I refers to States outside Latin America and the Caribbean which have de jure or de facto jurisdiction over territories which lie within the limits of the geographical zone established in the Treaty.*

Agreements providing for safeguards, other than those in connection with NPT or the Treaty of Tlatelolco, approved by the Board as of 31 December 1993

Party(ies)[a]	*Subject*	*Entry into force*	*INFCIRC*
(While the Agency is a party to each of the following agreements, only the State(s) party to them is (are) listed.)			
(i) Project agreements			
Albania	*Research reactor and fuel therefor*	*Approved by the Board, June 1991*	
Argentina	*Siemens SUR-100*	*13 March 1970*	*143*
	RAEP Reactor	*2 December 1964*	*62*
Chile	*Herald Reactor*	*19 December 1969*	*137*
Colombia	*Fuel for research reactor*	*Approved by the Board, Feb.1993 and amended, Dec.1993*	
Finland[b]	*FIR-1 Reactor*	*30 December 1960*	*24*
	FINN sub-critical assembly	*30 July 1963*	*53*
Ghana	*Research reactor and fuel therefor*	*Approved by the Board, Dec.1991*	
Greece[b]	*GRR-1 Reactor*	*1 March 1972*	*163*
Indonesia[b]	*Additional core-load for TRIGA Reactor*	*19 December 1969*	*136*
	Enriched uranium for materials test reactor fuel development	*15 January 1993*	
	Enriched uranium for the fabrication of isotope production targets	*15 January 1993*	
Iran, Islamic Republic of[b]	*UTRR Reactor*	*10 May 1967*	*97*
Jamaica[b]	*Fuel for research reactor*	*25 January 1984*	*315*
Japan[b]	*JRR-3*	*24 March 1959*	*3*
Malaysia[b]	*TRIGA-II Reactor*	*22 September 1980*	*287*
Mexico[b]	*TRIGA-III Reactor*	*18 December 1963*	*52*
	Siemens SUR-100	*21 December 1971*	*162*
	Laguna Verde Nuclear Power Plant	*12 February 1974*	*203*
Morocco[b]	*Fuel for research reactor*	*2 December 1983*	*313*
Pakistan	*PRR Reactor*	*5 March 1962*	*34*
	Booster rods for KANUPP	*17 June 1968*	*116*
Peru[b]	*Research reactor and fuel therefor*	*9 May 1978*	*266*
Philippines[b]	*PRR-1 Reactor*	*28 September 1966*	*88*
Romania[b]	*TRIGA Reactor*	*30 March 1973*	*206*
	Experimental fuel elements	*1 July 1983*	*307*
Slovenia[b]	*TRIGA-II Reactor*	*4 October 1961*	*32*
	Krško Nuclear Power Plant	*14 June 1974*	*213*
Spain[b]	*Coral-I Reactor*	*23 June 1967*	*99*
Syrian Arab Republic[b]	*Miniature neutron source reactor and enriched uranium*	*18 May 1992*	*408*
Thailand[b]*/United States of America*	*Fuel for research reactor*	*30 September 1986*	*342*
Turkey[b]	*Subcritical assembly*	*17 May 1974*	*212*
Uruguay[b]	*URR Reactor*	*24 September 1965*	*67*
Venezuela[b]	*RV-1 Reactor*	*7 November 1975*	*238*
Viet Nam[b]	*Fuel for research reactor*	*1 July 1983*	*308*
Zaire[b]	*TRICO Reactor*	*27 June 1962*	*37*
	Fuel for research reactor	*20 September 1990*	*389*

Table (cont.)

Party(ies)[a]	*Subject*	*Entry into force*	*INFCIRC*
(ii) Unilateral submissions			
Albania	*All nuclear material and facilities*	*25 March 1988*	*359*
Algeria	*Nur research reactor*	*9 April 1990*	*361*
	Es Salam research reactor	*2 June 1992*	*401*
Argentina	*Atucha Power Reactor Facility*	*3 October 1972*	*168*
	Nuclear material	*23 October 1973*	*202*
	Embalse Power Reactor Facility	*6 December 1974*	*224*
	Equipment and nuclear material	*22 July 1977*	*250*
	Nuclear material, material, equipment and facilities	*22 July 1977*	*251*
	Atucha II Nuclear Power Plant	*15 July 1981*	*294*
	Heavy water plant	*14 October 1981*	*296*
	Heavy water	*14 October 1981*	*297*
	Nuclear material	*8 July 1982*	*303*
Chile	*Nuclear material*	*31 December 1974*	*256*
	Nuclear material	*22 September 1982*	*304*
	Nuclear material	*18 September 1987*	*350*
Cuba	*Nuclear research reactor and fuel therefor*	*25 September 1980*	*298*
	Nuclear power plant and nuclear material	*5 May 1980*	*281*
	Zero-power nuclear reactor and fuel therefor	*7 October 1983*	*311*
Democratic People's Republic of Korea	*Research reactor and nuclear material for this reactor*[c]	*20 July 1977*	*252*
India	*Nuclear material, material and facilities*	*17 November 1977*	*260*
	Nuclear power station	*27 September 1988*	*360*
	Nuclear material	*11 October 1989*	*374*
Pakistan	*Nuclear material*	*2 March 1977*	*248*
	Miniature neutron source reactor	*10 September 1991*	*393*
	Nuclear power reactor	*24 February 1993*	*418*
Spain	*Nuclear material*[c]	*18 June 1975*	*221*
	Vandellos Nuclear Power Plant[c]	*11 May 1981*	*292*
	Specified nuclear facilities[c]	*11 May 1981*	*291**
United Kingdom	*Nuclear material*	*14 December 1972*	*175*
Viet Nam	*Research reactor and fuel therefor*[c]	*12 June 1981*	*293*
(iii) Agreements concluded with nuclear-weapon States on the basis of voluntary offers			
China	*Nuclear material in facilities selected from list of facilities provided by China*	*18 September 1989*	*369*
France	*Nuclear material in facilities submitted to safeguards*	*12 September 1981*	*290*

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* *Amended in 1985 to cover specified nuclear facilities. The amendment entered into force on 8 November 1985 (INFCIRC/291/Mod.1/Corr.1).*

Table (cont.)

Party(ies)[a]	*Subject*	*Entry into force*	*INFCIRC*
Russian Federation	*Nuclear material in facilities selected from list of facilities provided by the Russian Federation*	*10 June 1985*	*327*
United Kingdom	*Nuclear material in facilities designated by the Agency*	*14 August 1978*	*263*
United States of America	*Nuclear material in facilities designated by the Agency*	*9 December 1980*	*288*
(iv) Other agreements			
Argentina/Brazil		*Signed: 13 December 1991*	
Argentina/United States of America		*25 July 1969*	*130*
Austria[c]*/United States of America*		*24 January 1970*	*152*
Brazil/Germany[b]		*26 February 1976*	*237*
Brazil/United States of America		*31 October 1968*	*110*
Colombia/United States of America		*9 December 1970*	*144*
India/Canada[c]		*30 September 1971*	*211*
India/United States of America[d]		*27 January 1971*	*154*
Iran, Islamic Republic of[c]*/United States of America*		*20 August 1969*	*127*
Israel/United States of America		*4 April 1975*	*249*
Japan[c]*/Canada*[c]		*20 June 1966*	*85*
Japan[c]*/France*		*22 September 1972*	*171*
Japan/United Kingdom		*15 October 1968*	*125*
Korea, Republic of/United States of America		*5 January 1968*	*111*
Korea, Republic of[c]*/France*		*22 September 1975*	*233*
Pakistan/Canada		*17 October 1969*	*135*
Pakistan/France		*18 March 1976*	*239*
Philippines[c]*/United States of America*		*19 July 1968*	*120*
Portugal[c]*/United States of America*[e]		*19 July 1969*	*131*
South Africa/United States of America		*26 July 1967*	*98*
South Africa/France		*5 January 1977*	*244*
Spain/Germany[c]		*29 September 1982*	*305*
Spain[c]*/United States of America*[e]		*9 December 1966*	*92*
Spain/Canada[c]		*10 February 1977*	*247*
Sweden[c]*/United States of America*		*1 March 1972*	*165*
Switzerland[c]*/United States of America*[e]		*28 February 1972*	*161*
Turkey[c]*/United States of America*[e]		*5 June 1969*	*123*
Venezuela[c]*/United States of America*[e]		*27 March 1968*	*122*

(v) The Agency also applies safeguards under two agreements (INFCIRC/133 and INFCIRC/158) to the nuclear facilities in Taiwan, China. Pursuant to the decision adopted by the Board of Governors on 9 December 1971 that the Government of the People's Republic of China is the only government which has the right to represent China in the Agency, the relations between the Agency and the authorities in Taiwan are non-governmental. The agreements are implemented by the Agency on that basis.

[a] *An entry in this column does not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities or concerning the delimitation of its frontiers.*

[b] *Agency safeguards required by this (these) project agreement(s) are implemented pursuant to an agreement in connection with NPT covering the State indicated.*

[c] *Application of Agency safeguards under this agreement has been suspended in the State indicated as the State has concluded an agreement in connection with NPT.*

[d] *The trilateral safeguards agreement expired on 24 October 1993. However, India and the Agency agreed by exchanges of letters dated 1 October and 1 December 1993 to continue to be bound, until 1 March 1994, by the provisions of INFCIRC/154, Part I, insofar as they relate to the bilateral relationship between India and the Agency, as an interim measure pending the conclusion of a new agreement.*

[e] *Application of Agency safeguards under this agreement has been suspended in the United States of America in order to comply with a provision of INFCIRC/288.*

SAFEGUARDS OPERATIONS

Verification

While an inspection took place in the Democratic People's Republic of Korea at the end of January at the experimental power plant and the radiochemical laboratory with no limitations, only limited inspections were performed in May and August, restricted to the replacement of seals and video tapes at these two facilities. As a consequence, there were no inspections of the critical assembly, the subcritical assembly, the IRT reactor, the fuel fabrication plant or the fresh fuel storage in 1993. In addition, the verification of the initial inventory at the fuel fabrication plant remained to be completed. Also remaining to be completed was verification of the core of the experimental power plant; this will be performed at the time of reactor refuelling.

One and a half tonnes of plutonium shipped from Cogéma, France, were received in Japan in January. The plutonium content was verified upon receipt by the use of a newly installed NDA instrument coupled with a sample identification device, both operated in unattended mode. Continuity of knowledge of this verification was maintained for safeguards purposes through the use of MIVS in a dedicated plutonium storage area.

An improved version of the near real time accountancy software was successfully tested in a MOX fuel fabrication facility in Japan during the annual physical inventory verification (PIV) in January, with the full co-operation of the operator and the national authorities.

A new hot cell facility in Indonesia was brought under safeguards. The design information verification took place in February.

By the end of June, all design verification activities that could be carried out at a solution criticality facility in Japan had been completed; the remaining activities will be carried out in accordance with the remaining construction and commissioning activities. Agreement was reached on arrangements for design information verification during plant operation, the first such case in a complex facility.

Six thousand spent fuel elements containing a large amount of plutonium were verified at a nuclear power station and transferred under inspector supervision to a dry storage in the Republic of Korea. This required an inspection effort of 200 person-days.

The Agency verified that the transfer had started in Argentina of spent fuel bundles from a spent fuel store to on-site long term dry storage canisters. This operation started in March and continued throughout the year. Although adequate techniques exist for the verification of material transfer, the inability of the Agency to verify the design of already built concrete canisters is a major problem. Assistance has been requested from Member State support programmes.

As in previous years, simultaneous PIV inspections at facilities processing direct-use material and at those handling natural uranium were again successfully performed in Canada, utilizing low inspection resources under the zone approach safeguards scheme.

Safeguards inspection verification activities

	1991	1992	1993
Inspections performed	2 145	2 047	2 042
Person-days of inspection	9 442	8 385	8 153
Seals applied to nuclear material or Agency safeguards equipment detached and subsequently verified (including seals applied jointly with a group of States)	24 300	21 100	20 755
Optical surveillance films reviewed	3 300	3 260	2 847
Video tapes reviewed	1 065	2 060	3 072
Inspection samples analysed	1 090	1 439[a]	1 211[b]
Analytical results reported	2 830	3 240	3 000

[a] Including 372 samples taken by the IAEA Action Team under Security Council Resolution 687.

[b] Including 87 heavy water samples taken from routine inspections and 21 samples taken by the IAEA Action Team under Security Council Resolution 687.

***Verification** (cont.)*

From the time of the 'initial inspections' in late 1991, verification activities carried out in South Africa have been based on the Agency's 1991–1995 safeguards criteria. In October 1993, the Agency successfully carried out its second near-simultaneous verification of the inventories of nuclear material at all nuclear facilities.

The assessment of the completeness of South Africa's declaration regarding nuclear installations and material was conducted as a separate exercise. The extensive nuclear fuel cycle made the task complex, requiring considerable inspection resources and extensive co-operation from the State authorities in providing access to defunct facilities and historical operating records. The completeness exercise with respect to HEU was finalized and reported to the General Conference in September.

The Agency was invited by South Africa to examine all the facilities that had been involved in the nuclear weapons programme, to inspect all remaining records, to observe that the programme had been terminated and to gain assurance that all the nuclear material involved had been placed under safeguards. A team of senior Agency staff and nuclear weapons experts visited South Africa in April, June, August and November for these purposes. The team found substantial evidence of the destruction of the non-nuclear material components used in nuclear weapons and found no indication to suggest that substantial amounts of depleted or natural uranium used in the nuclear weapons programme are unaccounted for.

Implementation of the new partnership approach (NPA) with EURATOM was progressively introduced at different facility types. The savings in person-days of inspection (PDI) achieved were due mainly to the discontinuation, for practical purposes, of the observation and Joint Team regimes. Implementation was initiated at three LWRs without MOX and will be expanded to cover other such LWRs. Full implementation is expected by the end of 1994. Work on implementation of the NPA for other facility types is continuing.

The application of safeguards on irradiated fuel assemblies at a receipt and storage facility in a nuclear-weapon State started on 1 January. An initial inventory verification and subsequent monthly interim inspections were carried out. The fuel assemblies are received and stored in multi-element bottles. Ultrasonic bolt seals, designed specifically for this type of container, were tested and used for the first time.

Approximate quantities of material subject to Agency safeguards at the end of 1993

Type of material	Quantity of material (t)			
	INFCIRC/153[a]	INFCIRC/66[b]	Nuclear-weapon States	Quantity in SQs
Nuclear material				
Plutonium[c] contained in irradiated fuel	282.7	25.3	104.7	51 580
Separated plutonium outside reactor cores	10.7	0	26.8	4 699
Recycled plutonium in fuel elements in reactor cores	2.7	0.4	0	393
HEU (equal to or greater than 20% uranium-235)	9.5	0.3	0	237
LEU (less than 20% uranium-235)	27 919	2 112	8 693	10 423
Source material[d] (natural or depleted uranium and thorium)	57 786	3 543	24 827	5 680
Total significant quantities				73 012
Non-nuclear material[e]				
Heavy water	0	1 405	0	70

[a] Covering safeguards agreements pursuant to NPT and/or Treaty of Tlatelolco.

[b] Excluding installations in nuclear-weapon States; including installations in Taiwan, China.

[c] The quantity includes an estimated 70.5 t (8812 SQ) of plutonium in irradiated fuel, which is not yet reported to the Agency under the reporting procedures agreed to (the non-reported plutonium is contained in irradiated fuel assemblies to which item accountancy and C/S measures are applied).

[d] This table does not include material within the terms of subparagraphs 34(a) and (b) of INFCIRC/153 (Corrected).

[e] Non-nuclear material subject to Agency safeguards under INFCIRC/66/Rev.2-type agreements.

Number of facilities under safeguards or containing safeguarded material on 31 December 1993

Facility category	Number of facilities (number of installations)			
	INFCIRC/153[a]	INFCIRC/66/ Rev. 2[b]	Nuclear-weapon States	Total
Power reactors	153 (185)	13 (16)	1 (1)	167 (202)
Research reactors and critical assemblies	133 (144)	22 (22)	1 (1)	156 (167)
Conversion plants	7 (7)	4 (4)	0 (0)	11 (11)
Fuel fabrication plants	32 (34)	10 (10)	0 (0)	42 (44)
Reprocessing plants	5 (5)	1 (1)	0 (0)	6 (6)
Enrichment plants	5 (5)	1 (1)	2 (2)	8 (8)
Separate storage facilities	39 (39)	5 (5)	5 (5)	49 (49)
Other facilities	56 (60)	3 (3)	0 (0)	59 (63)
Subtotals	430 (479)	59 (62)	9 (9)	498 (550)
Other locations	296 (439)	28 (30)	0 (0)	324 (469)
Non-nuclear installations	0 (0)	3 (3)	0 (0)	3 (3)
Totals	726 (918)	90 (95)	9 (9)	825 (1022)

[a] Covering safeguards agreements pursuant to NPT and/or Treaty of Tlatelolco; excludes locations in Iraq.

[b] Excluding installations in nuclear-weapon States; including installations in Taiwan, China.

Negotiation of Subsidiary Arrangements

Some progress was made in the negotiation of Subsidiary Arrangements. Three new and 6 revised General Parts to Subsidiary Arrangements (three in 1992) and 29 (15 new and 14 revised) Facility Attachments (36 in 1992) entered into force:

- The General Part of the Subsidiary Arrangements with Algeria covering the Es Salam Research Reactor and the Facility Attachment for the Nur reactor entered into force in February. Negotiation of the Facility Attachment for the Es Salam Research Reactor is pending the provision by the State of changes in the design information, regarding additional items supplied by China to Algeria.
- The General Part of the Subsidiary Arrangements with Cuba covering a zero power nuclear reactor entered into force in June.
- The General Part of the Subsidiary Arrangements with Pakistan covering a miniature neutron source reactor entered into force in August.

Following the endorsement by the Board of Governors of the proposed improvements in the early provision and use of nuclear facility design information, revision of the relevant code of the Subsidiary Arrangements entered into force for five agreements.

The Subsidiary Arrangements with one State were revised to provide for substitution arrangements for MOX fuel. Amendments to Subsidiary Arrangements with another State were negotiated, to include the necessary substitution arrangements for natural uranium in the State.

Three new Facility Attachments entered into force, covering a hot cell complex and two fuel fabrication plants in South Africa.

Negotiations were held on the draft of the General Part to the Subsidiary Arrangements of the Quadripartite safeguards agreement between Argentina, Brazil, the ABACC and the Agency. Substantial progress was made, with all issues previously unresolved being agreed *ad referendum*. As at the end of 1993, ratification of the safeguards agreement by Brazil was still pending.

Draft Subsidiary Arrangements were proposed to Lithuania, and discussions are under way on the Facility Attachments for the power reactor. The initial verification of the fuel at the reactor was partially carried out, and preparations for additional safeguards measures were initiated.

Liaison with State authorities

Committee meetings and other regular forms of contact between the Agency and Member States continued to contribute to the further improvement of safeguards implementation. In particular, emphasis was placed on measures endorsed by the Board of Governors to enhance the effectiveness and efficiency of the safeguards system, including the early provision and use of design information and a reporting scheme on nuclear material and specified equipment and non-nuclear material. In addition, the potential benefits that could result from an enhancement of the role of SSACs in Agency safeguards was explored with several Member States.

A total of 18 fact finding missions or technical visits were carried out at most of the facilities in Armenia, Belarus, Kazakhstan, Kyrgyzstan, Ukraine and Uzbekistan. In close co-operation with State authorities and facility managers, information was collected in preparation for the development of safeguards approaches and for the implementation of safeguards. These visits also served as an opportunity to introduce the facility operators to the various aspects of safeguards implementation.

Nuclear material accountancy

As part of the ongoing task to improve the Agency's ability to optimize its verification activities, the Board of Governors endorsed a reporting scheme encouraging all Member States to report on a voluntary basis information on the export and import of all nuclear material, as well as information on the export of specified equipment and non-nuclear material. The Board also invited States to report the production of nuclear material and the import of specified equipment, to the extent possible. The object of the scheme is to help strengthen safeguards by enabling the Agency to build up its information base on the nuclear activities of States. Guidance on reporting modalities was provided to all Member States. Forty States and the European Union have so far indicated their willingness to participate in the scheme.

Total amounts of material exempted from safeguards during 1993

Type of material	INFCIRC/66		INFCIRC/153			
	Exemption by quantity		Exemption by quantity		Exemption by use	
	Number of States	Amount	Number of States	Amount	Number of States	Amount
Plutonium	0	0	0	0	0	0
Enriched uranium	1	48 g	1	4.3 g	2	7.52 g
Natural uranium	0	0	1	0.3 kg	1	0.1 kg
Depleted uranium	0	0	1	3 694 kg	9	22 411 kg
Thorium	0	0	0	0	3	88 kg
Heavy water	0	0	n/a	n/a	n/a	n/a

Facilities under Agency safeguards or containing safeguarded material on 31 December 1993

Power reactors

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Argentina	Atucha NPS	1	Lima	x
	Embalse PR	1	Embalse	—
Belgium	BR3-Mol	1	Mol	x
	DOEL-1	2	Doel	x
	DOEL-3	1	Doel	x
	DOEL-4	1	Doel	x
	Tihange-1	1	Tihange	x
	Tihange-2	1	Tihange	x
	Tihange-3	1	Tihange	x
Brazil	Angra-1	1	Angra dos Reis	x
Bulgaria	Kozloduy-I	2	Kozloduy	x
	Kozloduy-II	2	Kozloduy	x
	Kozloduy-III	2	Kozloduy	x
Canada	Bruce A	4	Tiverton	x
	Bruce B	4	Tiverton	x
	Darlington N.G.S.	4	Bowmanville	x
	Gentilly-2	1	Gentilly	x
	Pickering G.S.	8	Pickering	x
	Point Lepreau G.S.	1	Point Lepreau	x
China	QSNPP	1	Hai Yan	—
Cuba	Juragua	2	Juragua	x
Czech Republic	EDU-1	2	Dukovany	x
	EDU-2	2	Dukovany	x
Democratic People's Republic of Korea	Nyongbyon-1	1	Nyongbyon	—
Finland	Loviisa	2	Loviisa	x
	TVO-1	1	Olkiluoto	x
	TVO-2	1	Olkiluoto	x
Germany	AVR	1	Jülich	—
	KWG Grohnde	1	Grohnde	—
	GKN-2	1	Neckarwestheim	x
	RWE Biblis-A	1	Biblis	x
	RWE Biblis-B	1	Biblis	x
	KBR Brokdorf	1	Brokdorf	—
	KKB Brunsbüttel	1	Brunsbüttel	x
	KKE Emsland	1	Lingen	x
	KKG Grafenrheinfeld	1	Grafenrheinfeld	—
	KKI Isar-Ohu	1	Ohu bei Landshut	x
	KKI Isar-2	1	Essenbach	x
	KKK Krümmel	1	Geesthacht	x
	RWE Mühlheim-Kärlich	1	Mühlheim-Kärlich	x
	GKN Neckarwestheim	1	Neckarwestheim	x
	KWO Obrigheim	1	Obrigheim	x
	KKP Philippsburg-1	1	Philippsburg	x

Power reactors (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Germany (cont.)	KKP Philippsburg-2	1	Philippsburg	—
	KRB II Gundremmingen B	1	Gundremmingen	x
	KRB II Gundremmingen C	1	Gundremmingen	x
	KKS Stade	1	Stade	x
	KKU Unterweser	1	Unterweser	x
	KKW Würgassen	1	Würgassen	x
	KBG-KNK-II	1	Eggenstein-Leopoldshafen	x
	HKG-THTR 300	1	Hamm	—
	KKW Greifswald 1	2	Greifswald	—
	KKW Greifswald 2	2	Greifswald	—
	KKW Greifswald 3	1	Greifswald	—
	KKW Rheinsberg	1	Rheinsberg	—
Hungary	PAKS-I	2	Paks	x
	PAKS-II	2	Paks	x
India	RAPS	2	Rajasthan	x
	TAPS	2	Tarapur	x
Italy	ENEL-Latina	1	Borgo-Sabatino	x
	ENEL-Caorso	1	Caorso	x
	ENEL-Trino	1	Trino-Vercellese	x
Japan	Fugen	1	Tsuruga-shi, Fukui-ken	x
	Fukushima Dai-Ichi-1	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ichi-2	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ichi-3	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ichi-4	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ichi-5	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ichi-6	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ni-1	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ni-2	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ni-3	1	Futaba-gun, Fukushima-ken	x
	Fukushima Dai-Ni-4	1	Futaba-gun, Fukushima-ken	x
	Genkai-1	1	Higashimatsura-gun, Saga-ken	x
	Genkai-2	1	Higashimatsura-gun, Saga-ken	x
	Genkai-3	1	Higashimatsura-gun, Saga-ken	—
	Hamaoka-1	1	Ogasa-gun, Shizuoka-ken	x
	Hamaoka-2	1	Ogasa-gun, Shizuoka-ken	x
	Hamaoka-3	1	Ogasa-gun, Shizuoka-ken	x
	Hamaoka-4	1	Ogasa-gun, Shizuoka-ken	—
	Ikata-1	1	Nishiuwa-gun, Ehime-ken	x
	Ikata-2	1	Nishiuwa-gun, Ehime-ken	x
	Ikata-3	1	Nishiuwa-gun, Ehime-ken	—
	Joyo	1	Higashi-gun, Ibaraki-ken	x
	Kashiwazaki-1	1	Kashiwazaki-shi, Niigata-ken	x
	Kashiwazaki-2	1	Kashiwazaki-shi, Niigata-ken	x
	Kashiwazaki-3	1	Kashiwazaki-shi, Niigata-ken	—
	Kashiwazaki-4	1	Kashiwazaki-shi, Niigata-ken	—
	Kashiwazaki-5	1	Kashiwazaki-shi, Niigata-ken	x
	Mihama-1	1	Mikata-gun, Fukui-ken	x
	Mihama-2	1	Mikata-gun, Fukui-ken	x
	Mihama-3	1	Mikata-gun, Fukui-ken	x
	Monju	1	Tsuruga-shi, Fukui-ken	x

Power reactors (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Japan (cont.)	Ohi-1&2	2	Ohi-gun, Fukui-ken	x
	Ohi-3	1	Ohi-gun, Fukui-ken	x
	Ohi-4	1	Ohi-gun, Fukui-ken	x
	Onagawa-1	1	Oshika-gun, Miyaki-ken	x
	Sendai-1	1	Sendai-shi, Kagashima-ken	x
	Sendai-2	1	Sendai-shi, Kagashima-ken	x
	Shika	1	Hakui-gun, Ishikawa-ken	—
	Shimane-1	1	Yatsuka-gun, Shimane-ken	x
	Shimane-2	1	Yatsuka-gun, Shimane-ken	x
	Takahama-1	1	Ohi-gun, Fukui-ken	x
	Takahama-2	1	Ohi-gun, Fukui-ken	x
	Takahama-3	1	Ohi-gun, Fukui-ken	x
	Takahama-4	1	Ohi-gun, Fukui-ken	x
	Tokai-1	1	Tokai-Mura, Ibaraki-ken	x
	Tokai-2	1	Tokai-Mura, Ibaraki-ken	x
	Tomari-1	1	Furuu-gun, Hokkaido	x
	Tomari-2	1	Furuu-gun, Hokkaido	x
	Tsuruga-1	1	Tsuruga-shi, Fukui-ken	x
	Tsuruga-2	1	Tsuruga-shi, Fukui-ken	x
Korea, Republic of	Kori-1	1	Pusan	x
	Kori-2	1	Pusan	x
	Kori-3	1	Pusan	x
	Kori-4	1	Pusan	x
	Uljin-1	1	Uljin	x
	Uljin-2	1	Uljin	x
	Wolsung-1	1	Kyengju-kun, Kyongbuk-do	x
	Yongwang 1	1	Pusan	x
	Yongwang 2	1	Pusan	x
Lithuania	Ignalina NPP	2	Visaginas	—
Mexico	Laguna Verde	1	Alto Lucero	x
Netherlands	Borssele	1	Borssele	x
	Dodewaard NPP	1	Dodewaard	x
Pakistan	KANUPP	1	Karachi	x
Philippines	PNPP-1	1	Morong, Bataan	x
Slovak Republic	A1	1	Bohunice	x
	EMO-1	2	Mochovce	—
	V-1	2	Bohunice	x
	V-2	2	Bohunice	x
Slovenia	Krško	1	Krško	x
South Africa	Koeberg-1	1	Cape Town	x
	Koeberg-2	1	Cape Town	x
Spain	Almaraz-1	1	Almaraz	—
	Almaraz-2	1	Almaraz	—
	Asco-1	1	Asco	—
	Asco-2	1	Asco	—
	Cofrentes	1	Cofrentes	—
	José Cabrera	1	Almonazid de Zorita	—
	Santa María de Garona	1	Santa María de Garona	—

Power reactors (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Spain (cont.)	Trillo-1	1	Trillo	—
	Vandellos 1	1	Vandellos	—
	Vandellos 2	1	Vandellos	—
Sweden	Barsebäck I	1	Malmö	x
	Barsebäck II	1	Malmö	x
	Forsmark I	1	Uppsala	x
	Forsmark II	1	Uppsala	x
	Forsmark III	1	Uppsala	x
	Oskarshamn I	1	Oskarshamn	x
	Oskarshamn II	1	Oskarshamn	x
	Oskarshamn III	1	Oskarshamn	x
	Ringhals I	1	Göteborg	x
	Ringhals II	1	Göteborg	x
	Ringhals III	1	Göteborg	x
	Ringhals IV	1	Göteborg	x
Switzerland	KKB Beznau I	1	Beznau	x
	KKB Beznau II	1	Beznau	x
	KKG Gösgen	1	Gösgen-Däniken	x
	KKL Leibstadt	1	Leibstadt	x
	KKM Mühleberg	1	Mühleberg	x

Research reactors and critical assemblies

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Algeria	NUR Reactor	1	Algiers	x
	Es Salam research reactor	1	Ain Oussera	—
Argentina	RA-1 (reactor argentino-1)	1	Constituyentes	x
	RA-2 (reactor argentino-2)	1	Constituyentes	x
	RA-3 (reactor argentino-3)	1	Ezeiza	x
	RA-4 (reactor argentino-4)	1	Rosario	x
	RA-6 (reactor argentino-6)	1	Bariloche	x
	RA-0 (reactor argentino-0)	1	Córdoba	—
Australia	HIFAR	1	Lucas Heights	x
	MOATA	1	Lucas Heights	x
	CF	1	Lucas Heights	x
Austria	ASTRA	1	Seibersdorf	x
	Siemens Argonaut Reactor (SAR)	1	Graz	x
	Triga II	1	Vienna	x
Bangladesh	Atomic Energy Research Est.	1	Dhaka	x
Belgium	BR1-CEN	1	Mol	x
	BR2-CEN-BRO2	2	Mol	x
	CEN-Venus	1	Mol	x
	Thetis	1	Gent	x
Brazil	IEA-R1	1	São Paulo	x
	RIEN-1 Argonaut RR	1	Rio de Janeiro	x
	Triga-CDTN	1	Belo Horizonte	x
Bulgaria	IRT-2000	1	Sofia	x
Canada	McMaster	1	Hamilton	x
	NRU	1	Chalk River	x
	NRX	1	Chalk River	x
	Health and Physics	2	Chalk River	x
	Slowpoke-AECL	1	Ottawa	x
	Slowpoke-Dalhousie Univ.	1	Halifax	x
	Slowpoke-Ecole Polytechnique	1	Montreal	x
	Slowpoke-Kingston	1	Kingston	x
	Slowpoke-Saskatchewan	1	Saskatoon	x
	Slowpoke-Univ. of Toronto	1	Toronto	x
	Slowpoke-Univ. of Alberta	1	Edmonton	x
Chile	La Reina	1	Santiago	x
	Lo Aguirre	1	Santiago	x
China	HWRR	1	Beijing	—
Colombia	IAN-R1	1	Bogotá	—
Czech Republic	LR-O	1	Řež	x
	SR-OD	1	Vochov	x
	Univ. Training Reactor VR-1P	1	Prague	x
	VVR-S	1	Řež	x
Democratic People's Republic of Korea	Critical Assembly	1	Bungang-Ri, Nyongbyon	x
	IRT	1	Bungang-Ri, Nyongbyon	x

Research reactors and critical assemblies (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Denmark	DR-1	1	Roskilde	x
	DR-3	1	Roskilde	x
Egypt	RR-I	1	Inshas	x
Finland	Triga II	1	Otaniemi	x
Germany	BER-2	1	Berlin	x
	PTB	1	Braunschweig	x
	FRF-2	1	Frankfurt	x
	FRM	1	Garching	x
	GKSS-FRG1&FRG2	2	Geesthacht	x
	KFA-FRJ2	1	Jülich	x
	SUR 100	1	Bremen	x
	SUR 100	1	Eggenstein-Leopoldshafen	x
	SUR 100	1	Hannover	x
	SUR 100	1	Kiel	x
	SUR 100	1	Hamburg	x
	SUR 100	1	Ulm	x
	SUR 100	1	Stuttgart	x
	SUR 100	1	Furtwangen	x
	SUR 100	1	Darmstadt	x
	SUR 100	1	Berlin	x
	SUR 100	1	Aachen	x
	Tech. Univ. AKR	1	Dresden	x
	Tech. Hochschule ZLR	1	Zittau	x
	Triga	1	Mainz	x
	MHH-Triga	1	Hannover	x
	DKFZ-Triga	1	Heidelberg	x
	VKT RAKE&RRR	2	Rossendorf	x
	VKT research reactor	1	Rossendorf	x
Greece	GRR-1	1	Attiki	x
Hungary	Training reactor	1	Budapest	x
	WWR-S M	1	Budapest	x
Indonesia	Gama	1	Yogyakarta	x
	MPR-30	1	Serpong	x
	PPTN	1	Bandung	x
Iran, Islamic Republic of	TRR	1	Tehran	x
	HWZPR	1	Esfahan	—
	MNSR	1	Esfahan	—
Israel	IRR-1	1	Soreq	x
Italy	AGN-201	1	Palermo	x
	Poltec.	1	Milan	x
	RB-3	1	Montecuccolino	x
	RTS-1	1	San Piero a Grado	x
	TAPIRO	1	Santa Maria di Galeria	x
	Triga-RC1	1	Santa Maria di Galeria	x
	Triga-2	1	Pavia	x
Jamaica	Centre for Nuclear Sciences	1	Kingston	x

Research reactors and critical assemblies (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Japan	DCA	1	Oarai-machi, Ibaraki-ken	x
	FCA	1	Tokai-Mura, Ibaraki-ken	x
	HTR	1	Kawasaki-shi, Kanagawa-ken	x
	JMTR	1	Higashi-gun, Ibaraki-ken	x
	JMTRCA	1	Higashi-gun, Ibaraki-ken	x
	JRR-2	1	Tokai-Mura, Ibaraki-ken	x
	JRR-3	1	Tokai-Mura, Ibaraki-ken	x
	JRR-4	1	Tokai-Mura, Ibaraki-ken	x
	Kinki University reactor	1	Higashiosaka-shi, Osaka-fu	x
	KUCA	3	Osaka	x
	KUR	1	Sennan-gun, Osaka	x
	Musashi reactor	1	Kawasaki-shi, Kanagawa-ken	x
	N.S. Mutsu	1	Mutsui-shi, Aomori-ken	x
	NCA	1	Kawasaki-shi	x
	NSRR	1	Tokai-Mura, Ibaraki-ken	x
	Rikkyo University R.R.	1	Nagasaka, Kanagawa-ken	x
	TCA	1	Tokai-Mura, Ibaraki-ken	x
	TODAI	1	Tokai-Mura, Ibaraki-ken	x
	TTR	1	Kawasaki-shi, Kanagawa-ken	x
	VHTRC	1	Tokai-Mura, Ibaraki-ken	x
Korea, Republic of	Triga II&III	2	Seoul	x
	Kyung-Hee Univ.	1	Seoul	x
	KMRR	1	Daejon	—
Libyan Arab Jamahiriya	IRT Reactor	1	Tajura	x
Malaysia	Puspati	1	Bangi, Selangor	x
Mexico	Triga Mark III	1	Ocoyoacac	x
Netherlands	HOR	1	Delft	x
	HFR	1	Petten	x
	LFR	1	Petten	x
Norway	HBWR-Halden	1	Halden	x
	JEEP-II and Jeepnic	1	Kjeller	x
Pakistan	PARR-1	1	Rawalpindi	x
	PARR-2	1	Rawalpindi	—
Peru	Centro nucl. de investigaciones	1	San Borja	x
	RP-10	1	Lima	x
Philippines	PRR-1	1	Quezon City, Diliman	x
Poland	Agata&Anna	2	Świerk	x
	Ewa	1	Świerk	x
	Maria	1	Świerk	x
Portugal	RPI	1	Sacavem	x
Romania	Triga II	1	Piteşti Colibaşi	x
	VVR-S	2	Magurele	x
Slovenia	Triga II	1	Ljubljana	x
South Africa	SAFARI-1	1	Pelindaba	x

Research reactors and critical assemblies (cont.)

State[a]	Abbreviated name of facility	Number of reactor units	Location	Subsidiary arrangements in force
Spain	ARBI	1	Bilbao	—
	ARGOS	1	Barcelona	—
	JEN-1 and JEN-2	1	Madrid	—
Sweden	R2&R2-O	2	Studsvik	x
Switzerland	AGN 211P	1	Basel	x
	Crocus	1	Lausanne	x
	Proteus	1	Würenlingen	x
	Saphir	1	Würenlingen	x
Thailand	TRR-1	1	Bangkok	x
Turkey	Cekmece Nuclear Research Training Centre	1	Istanbul	x
	ITU-TRR Triga Mark II	1	Istanbul	x
Uruguay	Centro Investigaciones Nucleares	1	Montevideo	x
Venezuela	RV-I	1	Altos de Pipe	x
Viet Nam	Da Lat Research Reactor	1	Da Lat, Lam Dong	x
Yugoslavia (Serbia and Montenegro), Fed. Rep. of	RA-RB	2	Vinća	x
Zaire	Zaire Triga II	1	Kinshasa	x

Conversion plants, including pilot plants

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Argentina	UO_2 Conversion Plant	Córdoba	—
	Uranium Powders Fabrication Plant	Constituyentes	—
Canada	ENL	Port Hope	x
Chile	Lab. exper. de conversión	Santiago	x
Japan	JCO conv. plant	Tokai-Mura, Ibaraki-ken	x
	PNC Ningyo	Tomata-gun, Okayama-ken	x
	PCDF	Tokai-Mura, Ibaraki-ken	x
Romania	UO_2 powder fabrication plant	Feldioara	—
South Africa	Conversion plant	Pelindaba	—

Fuel fabrication plants, including pilot plants

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Argentina	FECRI	Ezeiza	—
	Atucha Fuel Fabrication Plant	Ezeiza	—
	Fuel Fabrication Plant (CANDU)	Ezeiza	—
	Pilot Fuel Fabrication Plant (HEU)	Constituyentes	x
	Research Reactor Fuel Fab. Plant	Constituyentes	—
Belgium	BN-MOX	Dessel	x
	FBFC	Dessel	x
	FBFC MOX Assembling Facility	Dessel	—
Brazil	Fuel Fabrication Plant Resende	Resende	x
Canada	CRNL Fuel Fabrication	Chalk River	x
	Fuel fabrication facility	Chalk River	x
	GEC pelletizing facility	Toronto	x
	General Electric FFP	Peterborough	x
	Zircatec P.I. Ltd	Port Hope	x
Democratic People's Republic of Korea	Nuclear Fuel Fabrication Plant	Nyongbyon	—
Denmark	Metallurgy	Roskilde	x
Germany	Adv. Nuclear Fuels	Lingen	x
	NUKEM	Wolfgang	x
	Siemens Uran (two units)	Hanau	x
	Siemens MOX	Hanau	x
India	Ceramic Fuel Fab Assembly Area	Hyderabad	x
	EFFP-NFC	Hyderabad	x
Indonesia	Experimental Fuel Element Installation (IEBE)	Serpong	x
	Research Reactor Fuel Element Production Installation (IPEBRR)	Serpong	x
Italy	Fabnuc	Bosco Marengo	x
Japan	JNF	Yokosuka-shi, Kanagawa-ken	x
	MNF	Tokai-Mura, Ibaraki-ken	x
	NFI (Kumatori-1)	Sennan-gun, Osaka	x
	NFI (Kumatori-2)	Sennan-gun, Osaka	x
	NFI (Tokai-Works)	Tokai-Mura, Ibaraki-ken	x
	PFPF	Tokai-Mura, Ibaraki-ken	x
	PPFF	Tokai-Mura, Ibaraki-ken	x
Korea, Republic of	CANDU Fuel Fabrication Plant	Daejeon	x
	KNFFP	Daejeon	x
Mexico	Fuel fabrication pilot plant	Ocoayacac	x
Romania	Romfuel	Piteşti Colibaşi	x
South Africa	MTR fuel fabrication	Pelindaba	x
	LEU fuel fabrication	Pelindaba	x
Spain	CIEMAT Planta Metall.	Madrid	—
	ENUSA Fuel Fabrication Plant	Juzbado	—
Sweden	ASEA-ATOM	Västeras	x

Chemical reprocessing plants, including pilot plants

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Democratic People's Republic of Korea	Radiochemical Laboratory	Bungang-Ri, Nyongbyon	—
Germany	WAK	Eggenstein-Leopoldshafen	x
India	PREFRE	Tarapur	x
Italy	EUREX	Saluggia	x
	ITREC-Trisaia	Rotondella	x
Japan	Tokai reprocessing plant	Tokai-Mura, Ibaraki-ken	x
In addition, the following R&D facilities are associated with reprocessing technology:			
Indonesia	*RMI*	*Serpong*	—
Japan	*NUCEF*	*Tokai-Mura, Ibaraki-ken*	*x*
	JAERI Tokai R&D	*Tokai-Mura, Ibaraki-ken*	*x*

Enrichment plants, including pilot plants

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Brazil	Enrichment plant Nuclei	Resende	x
Germany	URENCO Deutschland, UTA-1	Gronau	x
Japan	Uranium Enrichment Plant	Tomata-gun, Okayama-ken	x
	Rokkasho Uranium Enrichment Plant	Kamikita-gun, Aomori-ken	x
Netherlands	URENCO Nederland	Almelo	x
South Africa	Semi-commercial enrichment plant	Pelindaba	—
United Kingdom	BNF centrifuge plant and storage	Capenhurst	x
	BNF A3 plant	Capenhurst	—
In addition, the following R&D facilities and locations are associated with enrichment technology:			
Brazil	*Uranium Enrichment Training Bench*	*Nuclebras*	*x*
Germany	*Uranit*	*Jülich*	—
Japan	*Asahi Chemical Industry*	*Hyuga-shi, Miyazaki-ken*	*x*
	Hitachi Energy research laboratory	*Hitachi-shi, Ibaraki-ken*	*x*
	Nuclear Development Corp.	*Tokai-Mura, Ibaraki-ken*	*x*
	PNC Tokai R&D	*Tokai-Mura, Ibaraki-ken*	*x*
	Toshiba R&D Centre	*Kawasaki-shi, Kanagawa-ken*	*x*
Netherlands	*Urenco*	*Almelo*	*x*
	Ultra-centrifuge	*Almelo*	*x*

Separate storage facilities

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Argentina	Central store	Ezeiza	—
	Storage of depleted hexafluoride	Bariloche	—
	Storage of zircaloy tubes	Ezeiza	—
	Storage of 20% enriched uranium	Constituyentes	—
Belgium	Belgoprocess	Mol	x
	BN UF_6 store	Dessel	x
Bulgaria	Long term storage	Kozloduy	—
Canada	CRNL	Chalk River	x
	Spent fuel canister	Chalk River	x
	Douglas Point	Tiverton	x
	Gentilly-1	Gentilly	x
	Long term storage	Chalk River	x
	WNRE	Pinawa	x
Czech Republic	Storage Skoda	Bolevec	—
Democratic People's Republic of Korea	Nuclear Fuel Pool Storage	Bungang-Ri, Nyongbyon	—
Denmark	Risø Store	Roskilde	x
	Risø Waste	Roskilde	—
Finland	TVO-KPA store	Olkilouto	x
France	COGEMA UP2 & UP3	La Hague	x
Germany	Bundeslager	Wolfgang	—
	ANF UF6 Lager	Lingen	x
	KFA AVR BL	Jülich	—
	KFA AVR	Jülich	x
	KFK-FR-2	Eggenstein-Leopoldshafen	x
	BZA-Ahaus	Ahaus	—
	LSG Offset-Lager	Hanau	—
	NCS-Lagerhalle	Hanau	—
	Urananlage	Birkenfeld	x
	ZAB Greifswald	Greifswald	—
Hungary	Central radionuclide store	Budapest	x
Italy	FIAT deposito	Saluggia	x
	AGIP deposito	Bosco Marengo	x
	Essor Nuclear Plant	Ispra	—
	Essor Storage Pond	Ispra	x
	Ispra Central Store	Ispra	x
	Joint Research Centre	Ispra	—
Japan	KUFFS	Kyoto	x
Luxembourg	International Metals S.A.	Luxembourg-Dommeldange	x
Pakistan	Government Depot at Malir	Malir, Karachi	x
Portugal	Instalação de Armazenagem	Sacavem	x
Russian Federation	Mashinostroitel'nyi Zavod	Ehlektrostal	—
Slovak Republic	AFRS	Bohunice	x
South Africa	Waste Storage	Pelindaba	—
	Bulk storage facility	Pelindaba	—
Sweden	Central long term storage	Oskarshamn	x
Switzerland	Diorit Storage	Würenlingen	x
United Kingdom	Oxide Fuel Storage Pond	Sellafield	x
	Thorp R&S	Sellafield	x
	Special nuclear material store 9	Sellafield	x

Other facilities

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Argentina	Lab. de calificación	Constituyentes	—
	Lab. triple altura	Ezeiza	—
Australia	Research + Development Laboratories	Lucas Heights	x
Belgium	IRMM-Geel	Geel	x
	CEN-Labo	Mol	x
	CEN-Waste	Dessel	—
	I.R.E.	Fleurus	x
	CEN-lab. Pu	Mol	x
Czech Republic	Nuclear Fuel Inst. (UJP)	Zbraslav	x
	Research Laboratories	Řež	x
Democratic People's Republic of Korea	Subcritical Assembly	Pyongyang	x
Denmark	Hotcell Plant	Roskilde	x
Germany	DESY	Hamburg	—
	KFA-heisse Zellen	Jülich	x
	KFK-heisse Zellen	Eggenstein-Leopoldshafen	x
	KFK/IHCH	Eggenstein-Leopoldshafen	x
	Siemens heisse Zellen	Karlstein	x
	KFA Lab.	Jülich	x
	Transuran	Eggenstein-Leopoldshafen	x
	VKT.UT + LAB	Rossendorf	x
	VKT. Tec. ZTR	Rossendorf	—
Hungary	Institute of Isotopes	Budapest	x
Indonesia	RMI	Serpong	—
Iran, Islamic Republic of	LWSCR	Esfahan	—
	GSCR	Esfahan	—
Italy	CNEN-LAB. PU.	Santa Maria di Galeria	x
	CNEN-LAB. TEC.	Santa Maria di Galeria	x
Japan	JAERI-Oarai R&D	Higashi-gun, Ibaraki-ken	x
	JAERI-Tokai R&D	Tokai-Mura, Ibaraki-ken	x
	Kyoto University–Kumatori	Sennan-gun, Osaka	—
	Mitsui Iwakuni-Ohtake	Kuga-gun, Yamaguchi	—
	Mitsui Toatsu	Takai-shi, Osaka-fu	—
	NDC Fuel Hot Lab.	Tokai-Mura, Ibaraki-ken	x
	NDC fuel laboratories	Tokai-Mura, Ibaraki-ken	x
	NERL, University of Tokyo	Tokai-Mura, Ibaraki-ken	x
	NFD	Higashi-gun, Ibaraki-ken	x
	NFI Tokai-2	Tokai-Mura, Ibaraki-ken	x
	NRF Neutron Radiation Facility	Tsukuba-shi, Ibaraki-ken	x
	NUCEF	Tokai-Mura, Ibaraki-ken	x
	PNC FMF	Higashi-gun, Ibaraki-ken	x
	PNC IRAF	Higashi-gun, Ibaraki-ken	x
	PNC-Oarai R&D	Higashi-gun, Ibaraki-ken	x
	PNC-Tokai R&D	Tokai-Mura, Ibaraki-ken	x
	Showa-Kawasaki	Kawasaki-shi, Kanagawa-ken	—
	Sumitomo-Chiba	Sodegaura-shi, Chiba-ken	—
	Uranium Material Laboratory	Higashi-gun, Ibaraki-ken	x

Other facilities (cont.)

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Korea, Republic of	PIEF	Daejeon	x
Netherlands	ECN & JRC	Petten	x
Norway	Research laboratories	Kjeller	x
Poland	Institute for nuclear chemistry and engineering	Warsaw	—
	Institute of Nuclear Research	Świerk	x
South Africa	Decommissioned pilot enrichment plant	Pelindaba	—
	Decontamination and waste recovery	Pelindaba	—
	Hot Cell Complex	Pelindaba	x
	NU and DU metals plant	Pelindaba	—
Spain	CIEMAT Lab-Pu	Madrid	—
Sweden	Central storage fresh fuel	Studsvik	x
Switzerland	E.I.R.	Würenlingen	x
Turkey	Nuclear fuel pilot plant	Istanbul	—

Non-nuclear installations

State[a]	Abbreviated name of facility	Location	Subsidiary arrangements in force
Argentina	Heavy water plant	Arroyito	—
	Heavy water storage	Buenos Aires	x
Cuba	Storage of equipment	Prov. Havana	—

[a] An entry in this column does not imply the expression of any opinion whatsoever on the part of the Secretariat concerning the legal status of any country or territory or of its authorities, or concerning the delimitation of its frontiers.

Note: The Agency was also applying safeguards in Taiwan, China, at six power reactors, six research reactors/critical assemblies, one uranium pilot conversion plant, two fuel fabrication plants and one research and development facility.

Locations in Iraq containing nuclear material which are under the responsibility of the IAEA Action Team under Security Council Resolution 687

Reactor pond	Al Tuwaitha research centre
Location B	In the vicinity of Al Tuwaitha
Location C	In the vicinity of Al Tuwaitha

SUPPORT AND DEVELOPMENT

Instrumentation development and field support

The extrabudgetary Member State support programmes continued to provide major contributions to the research and development and safeguards implementation support activities. The role of support programmes is important in realizing the expectations for strengthening the safeguards system. Some 250 projects were under way, addressing safeguards needs identified by the Agency. During the year, bilateral meetings were held to review the status and activities of the programmes. In addition, a meeting of all support programme co-ordinators was held.

Additional support provided by States

States and organizations representing groups of States having formal support programmes	States having R&D contracts and test programmes
Australia Belgium Canada European Atomic Energy Community Finland France Germany Hungary Indonesia Japan Russian Federation Sweden United Kingdom United States of America	Argentina Austria Latvia Pakistan

Work continued on the development of instruments for specific applications in specific facilities as well as for general use. In particular, the following development and application tasks were successfully carried out during the year:

- Test measurements and a facility specific procedure for CANDU spent fuel dry storage canisters were completed.
- An in-facility test of the underwater telescope was successfully completed.
- The acceptance test for a BWR spent fuel attribute tester for old fuel stored in a long term storage facility was completed and used during a PIV.
- The Darlington core discharge monitor system and the compact surveillance and monitoring system (COSMOS) were authorized for inspection use.
- A demonstration of the improved Cerenkov viewing device system developed under a Member State support programme was successfully carried out in a facility. This system significantly improves the sensitivity of Cerenkov viewing devices. It is expected to be authorized for inspection use in 1994.
- Five instruction manuals for instrumentation and five standard procedures were completed and issued.

***Instrumentation development and field support** (cont.)*

Acceptance testing was carried out on two optical surveillance tape generic review stations: the multi-system optical review station and the MIVS advanced review station. When implemented, these systems will greatly reduce the effort required to review the surveillance tapes.

With the assistance of a Member State support programme, digital video standards, technical characteristics and recommendations for the Agency's next generation of digital image surveillance systems were completed and a development plan approved.

The development of a new generation of unattended radiation monitoring systems was initiated under a Member State support programme. This task is considered as a pilot project to explore a new equipment design standard, leading to a high degree of standardization of future safeguards equipment used by the Agency.

Implementation, maintenance and calibration services for safeguards equipment used by the inspectorate continued to be provided, including preventive maintenance and the servicing of equipment installed in facilities. An additional 20 MIVS systems were installed as well as four spent fuel bundle counters and three MXTV systems supporting 30 cameras. A total of 467 calibrations and 1349 maintenance/repairs were performed.

As a result of an extensive series of laboratory tests, it was proved that the higher than normal electromagnetic fields at nuclear facilities interfere in the operation of the MIVS systems. Solutions have been developed and added to the MIVS upgrade programme, and will be fully implemented as resources permit.

Further improvements were made in the safeguards equipment management information system. Programming and design standards were established, and issues concerning version change control and access control were resolved.

Performance monitoring activities continued on a number of safeguards instrumentation systems. Data from the performance monitoring programme made it possible to perform preventive equipment service and replacement, resulting in increased equipment reliability. Improvements were made on the data collection and evaluation for MIVS systems. A systematic monitoring programme for other surveillance systems as well as for NDA equipment is being developed.

The Safeguards Analytical Laboratory (SAL) and the Network of Analytical Laboratories (NWAL) performed 4095 measurements for calibration and quality control of NDA techniques, for certification of secondary reference samples, for maintenance and improvement of off-site destructive analysis (DA) and for testing procedures for on-site DA. In addition, 2615 measurements were performed by SAL and the NWAL for the routine quality control of the analysis of inspection samples. SAL also assisted in the measurement of samples taken in Iraq during inspections carried out pursuant to United Nations Security Council Resolution 687, and performed 26 such measurements. A total of 142 analytical results were reported by SAL on environmental type samples.

The median times required to complete verification by off-site DA were 67 days for uranium, 77 days for plutonium and 87 days for spent fuel samples.

Environmental monitoring studies and trials were initiated in 1993. This includes the extension of the NWAL to include the capability to make the very low level measurements associated with environmental samples and the

Main equipment and activities in support of safeguards

	1992	1993
Measurement instruments	Total inventory	
Low resolution gamma ray measurement devices	47	51
Portable multichannel analysers	94	99
High resolution gamma ray spectrometers	26	35
Neutron coincidence measurement units	59	51
Cerenkov glow viewing devices	54	65
Spent fuel verification instruments	42	63
Ultrasonic thickness gauges	28	42
Load cell based weighing systems	44	65
Other instrumentation	229	299
Monitoring instrumentation	Total in use	
Spent fuel bundle counters	26	30
Core discharge monitors	4	4
Portal/penetration monitor systems	3	3
Optical surveillance	Total in use	
Twin and triple Minolta camera photo units	225	200
Single camera video systems (MIVS)	142	162
Multiple camera video systems (MXTV, MOSS):		
— systems	12	14
— cameras	73	103
Seals		
Metal cap seals issued	12 600	14 700
Metal cap seals verified	12 334	13 676
Fibre optic loop seals in inventory	n/a	882
Ultrasonic seals in inventory	n/a	280
Activities		
Shipment of equipment and supplies	311	393
Hand carried transport of equipment and supplies	306	397
Shipment of reference material and chemicals to facilities	137	106
Shipment of inspection samples, radioactive material standards and contaminated items to SAL	210	180
Procurement actions	1 350	2 015

Instrumentation development and field support (cont.)

development of a class 100 clean room at the Safeguards Analytical Laboratory at Seibersdorf. The construction costs of the facility will be borne by extrabudgetary contributions.

With the assistance of Member State support programmes and the NWAL, the following major development activities were accomplished/pursued:

- Procedures were developed for X ray fluorescence analyses of mixed uranium-plutonium oxides and for the determination of 16 trace elements in uranium oxide samples.

Instrumentation development and field support *(cont.)*

- Studies were performed to further improve the precision and accuracy of thermal ionization mass spectrometry. Plans were formulated for installing a new thermal ionization mass spectrometer in a clean laboratory to be used for high sensitivity uranium and plutonium measurements on environmental samples.
- A new uranium automatic titrator using a robot arm was designed, built, installed and successfully validated. The automatic column exchange chromatographic procedure for analyses of spent fuel samples was optimized to obtain a higher decontamination of uranium in the plutonium fraction.
- A multidetector gamma spectrometry system was installed and put into routine use as was the software for computerized interpretation of alpha spectra for measurements of plutonium isotopic composition.
- The installation of an operational unit for the decontamination of alpha bearing analytical discards was completed. Commissioning of the system is anticipated in January 1994.

Development of a safeguards system for a large reprocessing plant in Japan (JNFS)

Work progressed on preparations for safeguards implementation at the large commercial reprocessing plant in Japan. As the spent fuel receipt and storage area will be the first part of the plant to enter service, discussions concentrated on safeguards concepts providing for unattended verification and dual C/S systems to minimize inspection effort and reduce or eliminate the need for remeasurements of the stored inventory. By the end of the year, almost full agreement had been reached on the concept and work had begun on agreed specifications for the equipment to be used.

The Agency and the Japanese Nuclear Material Control Center plan to operate a joint laboratory to carry out high accuracy measurements at the Rokkasho site. Detailed discussions were held to reach agreement on the measurements to be carried out, the equipment required, the layout of the 600 m^2 laboratory and working arrangements. Provisional cost estimates have been prepared and discussions are continuing into cost sharing arrangements. To keep inspection effort to a minimum, extensive use of unattended verification systems is foreseen. Preliminary discussions took place about possible arrangements and requirements for such a system, with a local area network to be incorporated into the plant to collect and assemble verification data.

Development of a safeguards system for a heavy water production plant in Argentina (PIAP–Arroyito)

In September, a team of Agency inspectors performed the first inspection at the Arroyito Heavy Water Production Plant to verify the design information. A preliminary safeguards approach was formulated and will be applied until the Quadripartite Safeguards Agreement between Argentina, Brazil, the ABACC and the Agency enters into force.

Development of a safeguards system for a Siemens–MOX fuel fabrication facility in Germany

The Siemens MOX-II plant is some 98% complete. However, commissioning and operation have been delayed at least into 1995 pending resolution of licensing matters. During the year work continued on the safeguards systems in accordance with the contract between Siemens-AG and the Inspectorates, EURATOM and the Agency, to ensure that safeguards can be implemented when required. Primary emphasis has been on the I-Point Measurement System (IPMS), the most complex of the safeguards systems. Fabrication of the IPMS hardware, including plutonium assay instrumentation, was completed. Factory acceptance testing took place in relation to the systems, including supporting software developed under a Member State support programme. The results are being evaluated.

Data processing development and services

The acquisition of safeguards related information contained in open sources (public media, scientific literature, etc.) was intensified, and efforts continued to develop and implement computerized systems to store and process this information.

Computerized systems were developed and implemented in accordance with the modalities suggested to Member States for the reporting of information on the export and import of nuclear material, certain specified equipment and non-nuclear material. Twenty-eight States and the European Union have so far provided reports to the Agency, 16 of these States indicating that there had been no occurrences to be reported.

Systems studies and approaches

An investigation continued into alternative interim safeguards approaches designed to improve, in the short term, the attainment of inspection goals for core fuel at multi-unit on-load refuelled reactors. A safeguards approach which makes use of the unique identification number inscribed on each CANDU fuel bundle continued to be elaborated.

Following the entry into force of the safeguards agreement between Lithuania and the Agency, and in connection with preparatory work for the implementation of safeguards in other States of the former USSR, a safeguards approach for RBMK-type reactors was further developed to take into account differences in specific reactor designs.

In support of SAGSI's work relating to the re-examination of current safeguards implementation and the elaboration of proposals for new and improved safeguards procedures, a cost-benefit study was performed on different ways of applying safeguards to spent fuel in States in which the Agency is able to provide some assurance of the absence of undeclared reprocessing.

Following established procedures, the Safeguards Research and Development and Implementation Support Programme for 1995-1996 was prepared and approved for implementation. The programme includes future needs, with emphasis placed on those relating to strengthening the safeguards system and improving its cost efficiency.

With the participation of three Member State support programmes, the Agency successfully conducted a procedural test of mail-in CCTV data. This approach was recommended by SAGSI as a high priority method of saving Agency inspection resources by eliminating the need for Agency safeguards inspectors to visit facilities (primarily LWRs) every three months. The approach represents one possible way to enhance safeguards efficiency by increased co-operation with the SSAC. The field test demonstrated the logistical feasibility of such kinds of co-operation after appropriate equipment is developed.

Previous studies for improving the cost effectiveness of safeguards implementation by broader use of the randomization principle were continued with the conduct of a field test of short notice random inspections for flow verification at a LEU fuel fabrication plant with the assistance of a Member State support programme. Preliminary evaluation showed a significant potential for improving effectiveness, even though the expected full coverage of flow items could not be achieved in the test.

Standardization

New models for statements provided to States on results and conclusions on safeguards activities performed under INFCIRC/153-type agreements were designed for implementation in 1994. The new models are intended to enhance

***Standardization** (cont.)*

communication with the State, in particular ensuring consistency with the results reported in the SIR and a clearer description of problems encountered during inspections.

The scope of the computerized inspection report system has been extended to include a material balance summary and evaluation results necessary for preparing statements of conclusions on safeguards activities performed for the material balance period. The modified system was approved for implementation in January 1994.

A total of 2114 inspection reports (2112 in 1992) and 2417 inspection statements (2387 in 1992) were reviewed and computerized quality control checks applied.

Reports on the quality and timeliness of inspection documentation packages were made routinely. The average time between an inspection and the dispatch of results to the State was 56 days (58 days in 1992).

Statistical analysis

Steps were initiated to improve statistical methods and software for personal computers, which contribute to further optimization of routine inspections. Improvements which enable the inspector to produce rapid on-site sampling plans and random item selections for verification measurements were successfully implemented in routine inspections. The development of new software which allows on-site material balance, as well as on-site operator–inspector difference evaluations to be made, is in progress.

A meeting of consultants on environmental monitoring and special analysis methods for safeguards was convened to develop and assess measures for detecting undeclared facilities and detecting undeclared activities at safeguarded facilities. The group provided a range of detailed recommendations for developing the Agency's environmental monitoring capabilities, including recommendations on expanding the Agency's analytical resources with certain specialized equipment and facilities (e.g. a clean room facility). Advice was given on the implementation of a multinational trial for short and long range monitoring to gain experience and build confidence in the use of such techniques. The report from the consultants meeting was provided to SAGSI in support of its work on developing recommendations for a strengthened and more cost effective safeguards system.

Two consultants meetings were held to finalize a report on international target values for uncertainty components in fissile isotope and element accounting for effective safeguarding of nuclear material. The report was published in October.

During 1993, 354 routine data evaluation reports were prepared, comprising material balance evaluations (141), operator–inspector pair evaluations (135) and verification performance history analyses (78). An annual summary of verification performance, covering all facilities, was prepared for DA and NDA measurements. New estimators for deriving verification measurement performance were developed and are undergoing simulation studies for selecting the most robust procedures. A computer code to load the material balance evaluation results into the computerized inspection report system was finalized for implementation in January 1994.

Throughout the year, a substantial effort was devoted to the organization and analysis of large quantities of sample data derived from inspection activities in Iraq pursuant to United Nations Security Council Resolution 687.

Safeguards training

During 1993, 26 training courses were conducted at Headquarters and in Member States. Eight other courses provided staff members with new and/or advanced skills applicable to management, data processing and other safeguards support areas. Individualized refresher training was given on C/S and NDA instrumentation.

The 1993 Safeguards Traineeship Programme involved five junior professionals from Member States receiving technical assistance under the regular programme. The training was carried out at Agency Headquarters and, as appropriate, at nuclear facilities in Austria, Germany and Hungary. The programme was funded by an extrabudgetary contribution from the USA.

Development of a safeguards system for the five-unit CANDU 600 nuclear power complex in Romania (Cernavoda Units 1 and 2)

The safeguards approach for the Cernavoda CANDU-600 complex was prepared, together with some further equipment development. This includes a reliable vault surveillance system based on new off-the-shelf self-contained radiation hardened tube cameras, a new Mark II spent fuel bundle counter developed under a Member State support programme and preparation for the later installation of a core discharge monitor.

All CCTV camera locations were selected and safeguards equipment power requirements lighting conditions, and installation deadlines agreed with the facility operator and contractors. The CCTV system was selected and will be installed in 1994. CCTV and core discharge monitor cables were installed. Both the on-site construction and safeguards equipment procurement are on schedule. It is expected that all safeguards systems will be in operation prior to the planned startup of the facility at the end of 1994.

Training courses and seminars held

Course name	Location	No. of participants	Duration
States systems of accounting and control	USA	35	2.5 weeks
States systems of accounting and control	Russian Federation	28	1.5 weeks
Workshop in accounting records and reports	Argentina	29	1 week
Safeguards methods for inspectors from Argentina and Brazil	Argentina	24	1 week

SAFEGUARDS MANAGEMENT

Planning, direction, co-ordination and control

SAGSI, with the additional members appointed by the Director General in 1992, held three regular meetings and three working group meetings primarily to complete its re-examination of safeguards implementation. The report was delivered to the Director General in April and was used as the basis for a Secretariat report to the Board of Governors in June on strengthening the effectiveness and improving the efficiency of Agency safeguards.

Effectiveness evaluation

The evaluation of inspection goal attainment in 1992 at facilities under safeguards was performed according to the 1991–1995 criteria. The areas in which the inspection goals could not be fully attained, for financial or other reasons, were identified and analysed. Conformity was established between the results reported to States in summary statements on inspection activities and the final evaluation results for 1992. The results of the evaluations were summarized in the SIR for 1992 and provided to the Board of Governors. Periodic evaluations were made on specific safeguards activities to assess the adequacy of inspection activities performed vis-à-vis the criteria for inspection goal attainment.

Provisional evaluations of inspection goal attainment were also performed on a continuous basis to assist the inspectors to resolve problem areas and to aid in effective planning of subsequent inspection activities. This information was generated for use in the SIR for 1993.

A mid-term review of the 1991–1995 criteria was initiated, with special emphasis on the need for clarifications arising out of implementation experience and for incorporating inspection requirements for new types of facilities coming under safeguards.

DIRECTION AND SUPPORT

ADMINISTRATION

Regular Budget

The General Conference appropriated an amount of $191 017 000 for the Agency's Regular Budget on the basis of an exchange rate of 12.70 Austrian Schillings to one United States dollar, of which $186 023 000 was related to Agency programmes. The latter amount was adjusted to $201 503 000 in accordance with the adjustment formula presented in the attachment to Resolution GC(XXXVI)/RES/593 in order to account for the average exchange rate of 11.58 Austrian Schillings to one US dollar which was actually experienced during the year. However, because of a shortfall in expected contributions, steps were taken to reduce the budget by 12% to $177 364 100.

The Regular Budget for 1993, at an exchange rate of 11.58 Austrian Schillings to one US dollar, amounted to $206 922 000, of which $198 259 000 was to be financed from contributions by Member States on the basis of the 1993 scale of assessment, $5 419 000 from income from reimbursable work for others and $3 244 000 from other miscellaneous income.

Expenditures

The actual expenditures for Agency programmes in 1993 amounted to $175 323 802. In addition, the authority to spend an amount of $16 628 800 was reserved for Deferred Programme Activities to be carried out in 1994 if arrears of contributions would be received in time. An allocation of $1 685 000 to the Equipment Replacement Fund was also approved. As a result, the unused budget amounted to $7 865 398.

In 1993, expenditures for the 1992 Deferred Programme Activities amounted to $10 151 441 from a total of $16 229 600 carried forward at 31 December 1992.

Voluntary contributions

The target for voluntary contributions to the Technical Assistance and Co-operation Fund in 1993 was established at $55.5 million, of which $43.0 million was pledged by Member States.

Extrabudgetary contributions

A total of $33 626 159 was offered in extrabudgetary contributions by Member States, the United Nations and other international organizations during 1993. Of this amount, $8 683 056 was in support of safeguards, $4 821 045 was for technical assistance projects, $2 847 153 for projects in the field of food and agriculture, $1 141 786 for nuclear safety and $12 904 329 for the implementation of United Nations Security Council Resolution 687 on Iraq. The remaining $3 228 790 was in support of various other projects implemented by the Agency.

In addition, extrabudgetary resources amounting to $15 582 533 (supplemented by the Agency's contribution of $1 387 916) were donated for the ICTP and $2 506 144 (supplemented by the Agency's contribution of $2 185 758) for the IAEA-MEL.

Trust funds

In 1993, a total of $1 363 349 was provided by Member States for technical assistance and co-operation activities as funds-in-trust. Furthermore, a total of $971 144 was administered on behalf of research institutions.

Personnel

At the end of 1993, the number of members of the Secretariat was 2188 — 833 in the Professional and higher categories and 1355 in the General Service category. These figures represent: regular staff (1637), temporary assistance staff (138), extrabudgetary (322), cost free experts (65) and consultants (26).

Among the 601 staff members in posts subject to geographical distribution, 85 nationalities were represented.

The General Conference adopted resolutions GC(XXXVII)/RES/621 and GC(XXXVII)/RES/622, which request the Director General to intensify efforts and take specific measures to increase the staff drawn from developing countries and the number of women in the Secretariat. A number of steps were taken internally as well as in respect of Member States to facilitate the implementation of the above two Resolutions. At the end of 1993 the percentage of women among the Professional staff was 15.6%; at the same time, G77 countries provided 27% of the staff subject to geographical distribution.

As part of the implementation of the deferred programme, a fourth Junior Professional Officer (JPO) from a developing country was selected to be trained in the Secretariat for one year.

With funds from the deferred programme available, the training programme was revived and two courses were held in November designed to increase managerial competence at middle levels. A new and improved language training programme at reduced cost was introduced for staff who want to acquire another official language or the language of the duty station.

The personnel part of the new payroll/personnel system, developed by an outside company with financial support from Germany, was completed and has been implemented.

Management services

A total of 14 projects aimed at promoting good management and cost effective working practices were completed during the year. They included management and efficiency reviews for determining the work-load and staffing requirements of various sectors, development of better management tools, and other studies and proposals for improving management operations.

Agreements concerning the administrative management of the International Centre for Theoretical Physics

In 1993 a tripartite Agreement was concluded between the Agency, UNESCO and the Government of Italy concerning the ICTP at Trieste. The Tripartite Agreement is intended to effect a number of changes in the management of ICTP. It transfers responsibility for the administration of ICTP from the Agency to UNESCO by replacing the Agency with UNESCO in the Seat Agreement (INFCIRC/114) with Italy. Moreover, the Agreement establishes a Steering Committee which will be responsible for the formulation of the general guidelines for the activities and budget of ICTP. The Committee will be composed of representatives of the three parties, i.e. UNESCO and the Agency (which are the present parties involved in the operation of the Centre), and the Government of Italy, which contributes about 84% of the funding. Others may be co-opted on the basis of contributions or special interest in the activities of the Centre. The Agreement also provides a long term arrangement for the funding of the Centre and changes the composition of the Scientific Council. The Agreement

Tripartite Agreement for the International Centre for Theoretical Physics (cont.)

has been signed and approved by the Agency and UNESCO. It has also been signed by the Italian Government and is awaiting approval by the Italian Parliament. The Agreement will come into force on 1 January of the year following its approval/ratification by the parties.

As a consequence of the provisions of the Tripartite Agreement, the agreement between the Agency and UNESCO, concerning the joint operation of the ICTP at Trieste (INFCIRC/132), has been amended. The amended agreement has been signed by the Agency and UNESCO and will come into force at the same time as the Tripartite Agreement.

Liability for nuclear damage

Strengthening and enhancing the international regime of nuclear liability remained a matter of priority. The Standing Committee on Liability for Nuclear Damage concentrated on the revision of the Vienna Convention and supplementary funding, where the results already achieved provided a basis for further progress. Consideration of revision of the Vienna Convention advanced substantially as a result of the adoption, for further consideration, of single texts of draft amendments on most of the issues under consideration. It was felt that the area of agreement that had been reached could allow early completion of the preparatory work on this question. With respect to supplementary funding, negotiations focused on the alternative systems suggested in two draft conventions (the 'levy' and 'pool' drafts). Consultations were initiated to help reach a common solution by inclusion of certain key elements of one draft into the other. There was also much interest in a proposal to insert in the revised Vienna Convention a higher amount of compensation which could be partly covered by public funds made available by the Installation State and would then serve as a threshold for a supplementary funding convention. Since differences of principle remained on international State liability and its relationship to the civil liability regime, consideration was given to proposals regarding some State involvement in the context of the revision of the Vienna Convention and supplementary funding.

The Standing Committee, given the close relationship between revision of the Vienna Convention and elaboration of a convention on supplementary funding, continued the simultaneous consideration of these topics with a view to the possibility to holding a single diplomatic conference. Accordingly, it was not felt opportune to recommend the convening of a diplomatic conference in 1993 on the revision of the Vienna Convention alone.

The question of nuclear liability was considered by the Board of Governors in September and by the thirty-seventh regular session of the General Conference. In the deliberations, the need to intensify the preparatory work in the Standing Committee was emphasized so that the diplomatic conference could be convened at an early date. It was also pointed out that broad participation in the third party liability regime would contribute to international co-operation in upgrading nuclear safety. Therefore, while work was under way to elaborate a strengthened and enhanced liability regime that could enjoy worldwide adherence, at this juncture it was important that the regime of the present Vienna Convention and the Joint Protocol should obtain the widest possible adherence.

The preparation of a nuclear safety convention

The group of technical and legal experts set up in 1992 by the Director General upon authorization of the Board of Governors continued its work on the main substantive elements of a nuclear safety convention. During 1993, the group met three times and reviewed a draft text of the convention prepared by the Chairman. INSAG provided comments on technical aspects of the convention.

***The preparation of a nuclear safety convention** (cont.)*

The General Conference, in resolution GC(XXXVII)/RES/615, considering that a nuclear safety convention adhered to by the greatest number of countries would constitute a significant step towards improving nuclear safety worldwide, urged the group of experts to continue its work and stressed the desirability of a diplomatic conference in 1994 to consider and adopt such a convention.

The present draft text of the nuclear safety convention provides that it should apply to ''nuclear installations'', defined as land based civil nuclear power plants. The obligations contained in the convention are based to a large extent on the 'principles' set out in a Safety Fundamentals document on the safety of nuclear installations. These obligations include the obligation for contracting parties to establish and maintain a legislative and regulatory framework for nuclear installations, and to implement a number of measures based on general safety considerations regarding, for example, the availability of financial and human resources, the assessment and verification of safety, quality assurance and emergency preparedness. Other obligations concern the technical aspects of safety and include siting, design, construction and operation of nuclear installations. In addition, the convention provides for an obligation of contracting parties to submit reports on the implementation of the convention to meetings of the contracting parties to be held at regular intervals. The draft provides that the Agency shall be the secretariat of the convention and the Director General its depositary.

Status of conventions and agreements

During 1993, three States succeeded to the Agreement on the Privileges and Immunities of the IAEA (reproduced in document INFCIRC/9/Rev.1). The number of Member States who have accepted the Agreement is now 65.

The Vienna Convention on Civil Liability for Nuclear Damage, which entered into force on 12 November 1977, now has 20 Parties as a result of accession by three States.

In 1993, eight States ratified, acceded or succeeded to the Convention on the Physical Protection of Nuclear Material (reproduced in document INFCIRC/274/Rev.1), which entered into force on 8 February 1987. Thus, by the end of the year there were 50 Parties.

The Convention on Early Notification of a Nuclear Accident (reproduced in document INFCIRC/335), which entered into force on 27 October 1986, was ratified, acceded or succeeded to by seven States, thus bringing the total number of Parties to 68 by the end of 1993.

The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (reproduced in document INFCIRC/336), which entered into force on 26 February 1987, was ratified, acceded or succeeded to by seven States. There were 68 Parties by the end of the year.

The Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention (reproduced in document INFCIRC/402) entered into force on 27 April 1992. During 1993, three States acceded. There are currently 12 States Parties to the Protocol.

The African Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Energy (AFRA) (reproduced in document INFCIRC/377), which entered into force on 4 April 1990, was accepted by two States during 1993. By the end of the year 17 States had accepted the Agreement.

***Status of conventions and agreements** (cont.)*

The Agreement to Extend the Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology, 1987 (RCA) (reproduced in document INFCIRC/167/Add. 15), entered into force on 11 June 1992. By the end of the year its status remained unchanged, with 14 States having accepted the Agreement.

TECHNICAL CO-OPERATION SERVICING AND CO-ORDINATION

General

The most significant development in 1993 in the Agency's technical co-operation activities was the approval by the Board of Governors of the first 12 model projects. These projects were formulated in close co-operation with the recipient governments, which are also willing to commit substantial resources to them. The model project concept, responding to real needs and designed to have a socioeconomic impact on end-users, has introduced a new approach to the Agency's technical co-operation programme.

During the year, all ongoing technical co-operation projects were reviewed and adjusted as necessary to facilitate better implementation. The reasons for delays in implementation were examined, and steps have been taken to improve the situation in the coming years.

In line with worldwide trends in technical assistance, environmental issues were emphasized. The Agency was represented at several United Nations follow-up meetings to the World Summit, and Agency proposals have been submitted to the Global Environment Facility and to Capacity 21.

Resources and implementation

Total new resources available for technical co-operation totalled $52.9 million, the largest amount ever recorded. All sources of funding were higher than in the previous year, with the Technical Assistance and Co-operation Fund (TACF) rising by 31%, extrabudgetary funding by 28%, assistance in kind by 26%, and funds from UNDP by 71%. The major source of funds continued to be the TACF with 82.9%, and the share of the $55 500 000 target met rose to 79.3%, the highest percentage since 1989.

The adjusted programme, which includes assistance brought forward, totalled $69 375 000. The overall implementation rate was 65.9%, a significant improvement over the rate of 59.3% in 1992. Total new obligations climbed to over $45.7 million, an increase of more than $10 million over the previous year.

Implementation by resource category

Resource category	Adjusted programme ($)	Share of total programme (%)	Net new obligations ($)	Implementation rate (%)
TACF	56 251 046	81.1	38 523 853	68.5
UNDP	1 377 143	2.0	1 059 234	76.9
Extrabudgetary	10 273 354	14.8	5 384 663	52.4
Funds-in-trust	1 473 496	2.1	759 816	51.6
Total	69 375 039	100.0	45 727 566	65.9

Programme delivery and support

During 1993, there were 1373 operational projects. This total comprised 860 projects continued from 1992, plus 412 newly approved core projects for the start of the biennial cycle and 44 training courses, 43 footnote-a/ projects, 11 Reserve Fund projects and three UNDP projects.

National and regional projects by area

Area	National projects	Regional projects	*Total*
Africa	291	37	328
Asia and Pacific	337	41	378
Europe	188	36	224
Latin America	306	38	344
Middle East	49	2	51
Interregional	0	48	48
Total	1171	202	1373

A record number of 2978 expert/lecturer assignments were carried out for a total of 1172 months. Fellowships, scientific visits and training courses provided 3898 months of training to 2504 persons. The total number of training courses was 172, which represented a significant increase from 128 in 1992. This training programme included 18 interregional, 82 regional and 72 national courses.

Technical co-operation programme delivery

	1989	1990	1991	1992	1993
Number of expert/lecturer assignments	2144	2221	2306	2258	2978
Number of expert/lecturer months served	1246	1217	1160	1009	1172
Number of expert/lecturer assignments undertaken by Agency staff	444	512	552	529	649
Number of purchase orders processed	3894	3763	3772	3315	3612
Number of fellows in the field	732	814	747	764	828
Number of visiting scientists	192	243	203	191	226
Number of participants in training courses	1265	1358	1401	1199	1450

The technical divisions of the Secretariat continue to play a vital role in technical co-operation activities. The technical officers in the Department of Research and Isotopes supported 930 projects and those in the Department of Nuclear Energy and Safety supported 392. A total of 1447 fellowship applications were evaluated, and Agency personnel undertook 649 assignments for a total of 173 months.

Technical co-operation activities carried out by area of activity

Area of activity	Number of technical officers	Number of projects supported	Number of fellowship applications evaluated	Number of expert/lecturer assignments	Number of months/days
Food and agriculture	28	267	279	69	17/17
Human health	15	194	199	68	20/14
Physical and chemical sciences	20	392	348	103	25/02
Agency's Laboratory	13	68	123	56	15/19
IAEA-MEL	8	9	14	5	3/22
Nuclear safety and radiation protection	48	236	224	172	48/02
Nuclear power	16	67	102	54	14/02
Nuclear fuel cycle and waste management	23	81	108	51	11/08
Scientific and technical information	5	8	26	5	1/18
Other	7	51	24	66	15/19
Total	183	1373	1447	649	173/03

Assistance to the different regions remained fairly constant. The Asia and Pacific region continued to receive the largest share, with 28.1%. Second was Africa, which again increased its share, to 23.7%.

The area of activity which received the largest share of disbursements in 1993 was food and agriculture, at 20.2%. This was followed by safety related activities, comprising radioactive waste management, radiation protection and the safety of nuclear installations, which received 19.7%. Physical and chemical sciences accounted for 18.1% of the total. Other significant programmes included industry and earth sciences with 14.5%, and human health with 14.4%.

Assistance provided to various regions

Region	Overall share (%)						
	1988	1989	1990	1991	1992	Average 1988–1992	1993
Africa	20.1	20.5	18.1	21.1	22.5	20.5	23.7
Asia and Pacific	29.0	29.6	31.8	29.8	26.3	29.3	28.1
Europe	13.8	13.4	16.3	14.4	15.2	14.6	14.3
Latin America	23.0	25.8	22.1	22.8	25.1	23.8	22.0
Middle East	3.0	2.1	2.4	2.8	2.8	2.6	2.7
Interregional	11.1	8.6	9.1	9.1	8.1	9.6	9.2

Note: Assistance provided on the basis of disbursements from all sources of funds.

Distribution of technical co-operation disbursements by programme and region

Programme	Inter-regional	Africa	Latin America	Asia and Pacific	Europe	Middle East	*Total*
Nuclear power	475.2	131.7	273.5	1 026.1	878.9	13.5	2 798.9
Nuclear fuel cycle	164.9	369.5	161.0	662.0	89.4	8.0	1 454.8
Radioactive waste management	174.4	199.4	145.3	307.7	185.1	3.8	1 015.7
Comparative assessment[a]	0.0	0.0	0.0	0.0	65.8	0.0	65.8
Food and agriculture	520.8	3 421.0	2 348.2	2 292.2	393.9	160.5	9 136.6
Human health	213.9	2 307.5	1 633.7	1 950.9	376.3	38.1	6 520.4
Industry and earth sciences	128.6	1 015.9	2 242.9	2 001.1	995.0	174.8	6 558.3
Physical and chemical sciences	451.3	1 919.4	1 667.5	2 442.5	1 144.9	580.9	8 206.5
Radiation protection	246.6	1 259.2	1 058.6	841.8	827.1	211.5	4 444.8
Safety of nuclear installations	744.4	71.2	318.0	882.0	1 466.8	0.0	3 482.4
Safeguards	0.0	0.0	0.0	17.3	0.0	0.0	17.3
Direction and support	1 041.8	38.6	110.8	301.2	78.4	25.7	1 596.5
Total	4 161.9	10 733.4	9 959.5	12 724.8	6 501.6	1 216.8	45 298.0

Note: All figures are in thousands of dollars.

[a] The full title of this area of activity is: 'Comparative assessment of nuclear power and other energy sources'.

Evaluation

In depth 'Desk Evaluations' of one industrial and three agricultural technical co-operation projects were carried out. At the request of the Board of Governors, these evaluations included for the first time reviews of two projects some time after their completion.

Routine evaluation activities in 1993 included the preparation of 22 ten-year country programme summaries, intended to provide a comprehensive picture of the Agency's co-operation activities with Member States. These are particularly useful for programming decisions. Operational country programmes continued to be monitored through the Interim Project Implementation Report (IPIR) system; interregional and AFRA training courses were monitored through follow-up questionnaires.

Some of the wider issues with regard to technical co-operation activities were reviewed in depth, including the Agency's technical co-operation with least developed Member States, the RAPAT and WAMAP programmes in Asia and the Pacific, and the lessons learned from completed evaluation reviews during the past ten years.

SPECIALIZED SERVICE ACTIVITIES

Public information

Public information work was largely oriented toward meeting the growing level of media and public interest in the Agency's activities. The interest concentrated on the difficulties experienced by safeguards inspection teams in the Democratic People's Republic of Korea and the many related discussions and resolutions of the Board of Governors. In addition, there was continuing media interest in the Agency's activities in Iraq under United Nations Security Council Resolution 687 as well as in the ongoing Agency safeguards activities in South Africa. The Agency's own film team went to Iraq to document milestone events there for inclusion in a documentary.

The safety related activities of the Agency, notably in central and eastern Europe and the former USSR, also attracted major media attention.

As in previous years, a range of press releases and publications were produced highlighting the Agency's technical co-operation activities.

Under the enhanced public information programme in 1993, seminars on nuclear energy topics were held at several locations including Santiago (Chile), Jadwisin (Poland), Seoul (Republic of Korea), Shanghai (China) and Vienna.

INIS

Developments in INIS were aimed at simplifying the process of preparing input to the database so as to reduce costs at the national centres of Member States. A redesign of the data processing system is in progress to make better use of innovative information technology.

Ethiopia, Kenya, Nicaragua, Slovakia and Slovenia joined INIS during 1993, bringing the number of participating Member States to 86, together with 17 international organizations.

A total of 71 116 records of published literature were added to the INIS database and announced in the abstracting journal *INIS Atomindex*, bringing the total number of records available in the database to 1 700 078. The quality control of the input submitted by Member States has been made more effective by an expert system which provides identification of input items requiring correction.

In order to achieve more efficient and error-free input at the national centres, the PC software package FIBRE (Friendly Inputting of Bibliographic Records), was significantly enhanced and a new version was distributed to 33 countries towards the end of the year. The new version permits consultation of all the INIS authorities and single-keystroke selection of appropriate data from any authority with transfer to the correct field of the input record being prepared.

The INIS database is currently being sent on CD-ROM to 82 INIS members and on tape or cartridge to 23 members. Through arrangements made by a number of Member States with database hosts, the INIS database is available on-line in many countries from various commercial and non-commercial sources. It also continues to be available on-line from the Agency's computer system in Vienna, where it was used for a total connect-time of about 250 hours in 1993.

***INIS** (cont.)*

The INIS Clearinghouse distributed the full text of non-conventional literature (reports, dissertations, etc.) on microfiche with a volume of about 440 000 microfiches, representing 24 million printed pages of documents. Thirty INIS members have standing orders for the full microfiche collection. By the end of 1993, the number of documents available on microfiche was almost 278 000.

The 21st Consultative Meeting of INIS Liaison Officers was held in May. The Liaison Officers discussed and made recommendations on a new revision of the document *Definition of Membership Arrangements for INIS*, which forms the basis on which the system operates. They also made further recommendations on the User Needs Study, on the indexing methodology, on developments for storing the full text of documents on optical media and on the electronic exchange of bibliographic data. A Technical Committee meeting was held to discuss specific details of the User Needs Study, storage on optical media, simplifying the INIS record format, and changes in the characteristics of a number of INIS authorities.

Work was completed on the Arabic version of the promotional booklet *Presenting INIS*, this being a voluntary contribution by the Syrian INIS centre.

Training courses and seminars held

Course name	Location	No. of participants	Duration
Group fellowship	France	4	4 weeks
Group fellowship	Russian Federation	13	5 weeks
INIS operations	Headquarters	37	1 week

SHARED SUPPORT SERVICES

Library services

The VIC Library implemented major changes in its computer and telecommunications infrastructure. Personal computer workstations were installed, along with a local area network and standard software packages for word processing, mail and spreadsheets, bringing the Library in line with the Agency's Standard Technology Architecture (STA). This new configuration formed the environment for the installation of VIC LION, a commercially procured integrated library system. VIC LION was installed at mid-year and data from the Library's current computer system was converted and transferred to the new system. Acceptance testing was continuing at the end of the year. With the transition to VIC LION, the Library for the first time adopted international standards for bibliographic record format and content. Other major projects in 1993 included an in-depth review of all journals received via gift or exchange; the review and documentation of the Library's collection management policy; and the institution of a new individualized current awareness profile service covering new issues of a large number of important journals.

Central computer services

At the end of the year, there were more than 1500 workstations of various types in the Agency. During 1993, over 600 personal computers were ordered. The central Help Line continued to grow, with over 4000 calls in the last six months of the year for help in solving equipment or software problems.

During 1993, applications developed by central computer services using the new STA went into production in the Departments of Nuclear Energy and Safety, Administration, and Research and Isotopes. The Departments of Safeguards and Technical Co-operation developed their own applications. Under development are applications for standard departmental databases and for various UNIX based equipment.

A major emphasis in 1993 was the introduction of departmental local area networks (LANs). At the end of 1993 over 30 LANs were centrally managed. As planned, all dependence on Wang equipment for word processing was discontinued. The General Conference session was supported with standard personal computer and LAN equipment for the first time. Approximately half of the Agency's staff attended training courses for basic standard PC and LAN skills (DOS and Windows and WordPerfect), plus courses in spreadsheets, databases, graphics and electronic mail.

Electronic mail (e-mail) was introduced as a service in the LAN environment in mid-1993, replacing the mainframe based mail service. By the end of the year the majority of the staff in the Departments of Nuclear Energy and Safety, Administration, and Safeguards had access to e-mail. The e-mail service includes access to international networks such as Internet and EARN.

The Agency became an active participant in the international network community in 1993, with the introduction of Internet services for Agency staff and the provision of Agency public information to the worldwide Internet community. The first Agency information to be provided is the listing of Agency professional vacancy notices.

Publishing

Nearly two hundred titles and journal issues were prepared for press and published. In addition to those listed or mentioned in other parts of the Annual Report, four books were issued in Chinese, seven in French, ten in Russian and nine in Spanish.

Of particular note amongst the books published in 1993 were:

- *IAEA-UNDP Forum on Strengthening Radiation and Nuclear Safety Infrastructure in Countries of the Former USSR,*
- *Financing Arrangements for Nuclear Power Projects in Developing Countries: A Reference Book,*
- *Code on the Safety of Nuclear Research Reactors: Design,*
- *Code on the Safety of Nuclear Research Reactors: Operation,*
- *The Chernobyl Accident: Updating of INSAG-1,*
- *The Safety of Nuclear Installations (Safety Fundamentals).*

The full set of subject oriented publications catalogues and the complete Agency catalogue were produced and issued.

Agreement was reached with Ontario Hydro, Canada, for the Agency to take over and market a diskette version (with special search software) of the publications related to the safe transport of radioactive materials.

Printing

The Common Printing Service continued to provide document and publications printing services for the Agency and also for UNIDO and the United Nations bodies based in the VIC. In 1993, the income from work for other organizations amounted to around $1.985 million. The output of the Common Printing Service was 163 million page impressions, compared with 186 million in 1992.

MATTERS PERTAINING TO THE BOARD OF GOVERNORS AND GENERAL CONFERENCE

The year 1993 was a productive one for the Board of Governors and the General Conference. Decisions and resolutions adopted by the Agency's Policy-making Organs resulted in considerable activity; these are set out extensively elsewhere in this report. However, a few matters not dealt with explicitly are highlighted here:

- Acting on the unanimous recommendation of the Board of Governors, the General Conference — also acting unanimously — approved in September 1993 the appointment of Hans Blix as Director General for a further term of four years starting on 1 December 1993.
- The General Conference approved six applications for membership of the Agency: Armenia, the Czech Republic, Kazakhstan, the Marshall Islands, the Slovak Republic, and "The Former Yugoslav Republic of Macedonia".
- The General Conference and the Board of Governors continued discussions on a possible review of the composition of the Board, long term arrangements for the future financing of safeguards, and methods of obtaining predictable and assured resources for technical assistance. Working Groups of the Board were set up to deal with each of these issues. Unfortunately, the Working Group relating to the financing of technical assistance was unable to meet. The other groups met and submitted reports to the Board and the General Conference. The Conference decided, in September 1993, to request the Board to re-establish all three Working Groups. These were re-established by the Board in October 1993. Additionally, at the request of the General Conference and the Board of Governors, the Secretariat invited Member States to submit written comments by 28 February 1994 on a possible review of the membership of the Board.

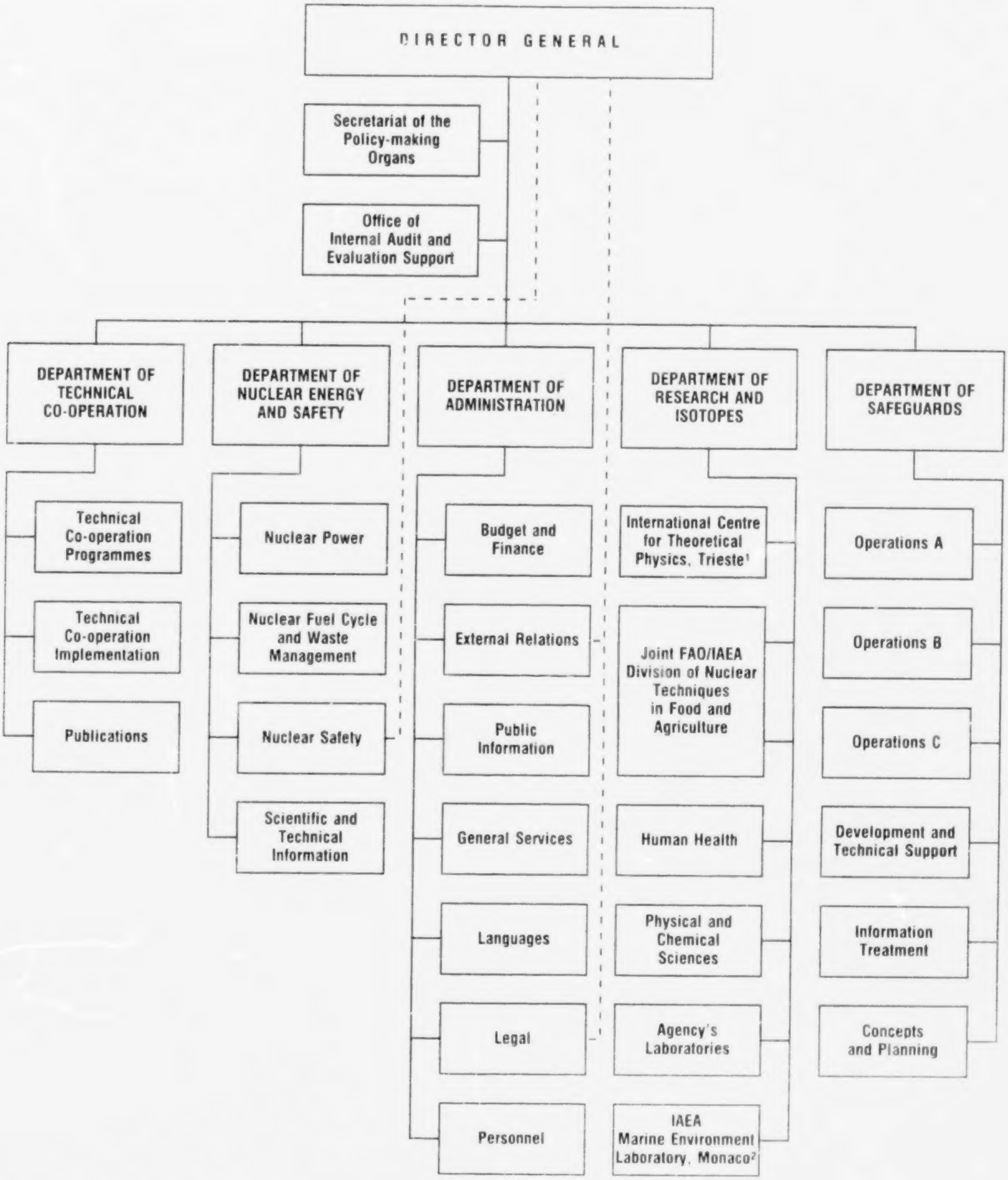
LIST OF ABBREVIATIONS

ARCAL	Regional Co-operative Arrangements for the Promotion of Nuclear Science and Technology in Latin America
BWR	Boiling water reactor
CANDU	Canadian deuterium-uranium (reactor)
CEC	Commission of the European Communities
CRP	Co-ordinated research programme
ESCAP	United Nations Economic and Social Commission for Asia and the Pacific
EURATOM	European Atomic Energy Community
FAO	Food and Agriculture Organization of the United Nations
FORATOM	Forum atomique européen
HEU	High enriched uranium
HTGR	High temperature gas cooled reactor
HWR	Heavy water reactor
IAEA-MEL	IAEA Marine Environment Laboratory
ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units and Measurements
ICTP	International Centre for Theoretical Physics
IEA	International Energy Agency (OECD)
IIASA	International Institute for Applied Systems Analysis
ILO	International Labour Organisation
IMO	International Maritime Organization
INDC	International Nuclear Data Committee
INIS	International Nuclear Information System
ISO	International Organization for Standardization
LEU	Low enriched uranium
LMFBR	Liquid metal fast breeder reactor
LWR	Light water reactor
MAED	Model for Analysis of Energy Demand
NDA	Non-destructive assay
NEA	Nuclear Energy Agency of the OECD
NUSS (programme)	The Agency's programme on nuclear safety standards for nuclear power plants
OAU	Organization for African Unity
OECD	Organisation for Economic Co-operation and Development
OLADE	Organización Latinoamericana de Energía
OPANAL	Organismo para la Proscripción de las Armas Nucleares en América Latina y el Caribe
OPEC	Organization of Petroleum Exporting Countries
PAHO	Pan American Health Organization/WHO
PHWR	Pressurized heavy water reactor
PWR	Pressurized water reactor
RCA	Regional Co-operative Agreement for Research, Development and Training Related to Nuclear Science and Technology
SG	Department of Safeguards (IAEA)
SQ	Significant quantity
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme

UNESCO	United Nations Educational, Scientific and Cultural Organization
UNIDO	United Nations Industrial Development Organization
UNIPEDE	International Union of Producers and Distributors of Electrical Energy
UNSCEAR	United Nations Scientific Committee on the Effects of Atomic Radiation
UNU	United Nations University
VIC	Vienna International Centre
WANO	World Association of Nuclear Operators
WASP	Wien Automatic System Planning Package
WEC	World Energy Council
WHO	World Health Organization
WISE	World Information Service on Energy
WMO	World Meteorological Organization
WOCA	World outside centrally planned economies area
WWER	Water cooled and moderated reactor (former USSR)

ORGANIZATIONAL CHART

(as of 31 December 1993)


DIRECTOR GENERAL
Secretariat of the Policy-making Organs
Office of Internal Audit and Evaluation Support
DEPARTMENT OF TECHNICAL CO-OPERATION
Technical Co-operation Programmes
Technical Co-operation Implementation
Publications
DEPARTMENT OF NUCLEAR ENERGY AND SAFETY
Nuclear Power
Nuclear Fuel Cycle and Waste Management
Nuclear Safety
Scientific and Technical Information
DEPARTMENT OF ADMINISTRATION
Budget and Finance
External Relations
Public Information
General Services
Languages
Legal
Personnel
DEPARTMENT OF RESEARCH AND ISOTOPES
International Centre for Theoretical Physics, Trieste[1]
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
Human Health
Physical and Chemical Sciences
Agency's Laboratories
IAEA Marine Environment Laboratory, Monaco[2]
DEPARTMENT OF SAFEGUARDS
Operations A
Operations B
Operations C
Development and Technical Support
Information Treatment
Concepts and Planning

[1] Jointly operated by the Agency and UNESCO.

[2] With the participation of UNEP.